THE EOCENE BEDS OF THE KOHAT DISTRICT

by

Lt.Col.L.M.Davies, M.A., F.G.S.

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1. Location, Boundaries etc. of the District.

The Kohat district forms part of the North-West Frontier Province. It s bounded by the river Indus on the east, by part of the Peshawar district n the north-east, by the Tirah along most of its northern border, by the uri country on the north-west, by Waziristan on the west, and by the Bunnu nd Mianwali districts on the south-west and south-east respectively. Its hape is indicated by Text-figure 1, and its area is approximately 2,500 quare miles.

2. Previous Geological Work on the District.

The geologist who did the most work on the Kohat district in the past as Mr.A.B.Wynne of the Geological Survey of India. He mainly dealt with ith the southern half of the district, and the results of his work on the ame were published in two memoirs dated 1875 and 1880. Although strati-raphic terminology was less developed in his day than it is now, and the opographical maps with which he was provided were much less accurate than hose which are available to the modern geologist, Wynne's observations ere so detailed and consistent, while dealing with this area, that the eology of the southern parts of the Kohat district can still be regarded s having been fairly well worked out. The regions covered by Wynne during hese two surveys are indicated on Text-figure 1.

The northern parts of the Kohat district were also seen by Wynne, for e passed through them during the second Afghan war, but he had no time to xamine them in detail. Much of what is now included in the northern half f the Kohat district was then still in tribal hands and could not be seen y him at all; and his movements were in any case restricted, by exigencies f time and transport, to the vicinity of the Khushalgarh-Thal road. Wynne's bservations on this half of the district are recorded in a short paper ated 1879 (the martial spirit of the day appearing in his choice of a mil-ary term - which is incidentally misspelt - for the title of this paper). though he succeeded in noting the general distributions of secondary and rtiary beds taken as wholes (no mean achievement under the circumstances) nne was unable to map them exactly, and made no attempt to subdivide the cene into its component parts. Indeed, his unfamiliarity with the local quence caused him to misinterpret the principal exposures which he saw,

and considerably overestimate the total thickness of Eocene deposits exist-
ing in this region.

Observations by later workers were very fragmentary, although Mr.C.L.
riesbach and Mr.(afterwards Sir Henry) Hayden, both of the Geol.Survey of
ndia, published notes on the Samana range - which lies on the northern
order of the Kohat district - in 1892 and 1898 respectively, after the
ilitary operations of 1891 and 1897 in that region. These notes did
ittle, however, even to elucidate the geology of that range (which Wynne
ad been unable to approach); and although Dr.(now Sir Edwin) Pascoe of the
eol.Survey also published descriptions of the Eocene beds at Tarkhobi at
he north-eastern end of the Kohat district, he said (p.447) at the same
ime (1920) that little was known of the northern Kohat district west of
he Indus. Hence Dr.G.E.Pilgrim of the Geol.Survey, when writing to me in
he same year (1920) after hearing that I was to take over the command of a
nit at Kohat, suggested that I should try to work out the geology of the
orthern parts of that district. The unit itself offered unique facilities
or this, since it consisted of an artillery brigade with headquarters at
ohat and detachments in twelve other posts distributed over more than 400
iles of frontier, from Swat in the north to Baluchistan in the south. I
herefore tried, while visiting outposts from 1920 to 1926, to compare the
ocks found over this portion of north-west India, and in particular to
ork out the stratigraphic details of the less known parts of the Kohat
istrict.

In doing this, I received much help from Dr.Pilgrim himself and from
ther Officers then on the Staff of the Geol.Survey of India, notably Drs.
ascoe, Coggin Brown and Cotter, and Messrs.Tipper and Wadia. I was conse-
uently able to produce a number of papers describing the geology of Kohat
tself, Bahadur Khel, Thal and the Samana range; the palaeontology of the
amana range being worked out in conjunction with British geologists after
y return to England in 1926. I myself latterly concentrated on the study
f the foraminifera, which I found to be the most important forms when deal-
ng with the Kohat district, owing to the exceptionally fine development of
ossiliferous Eocene beds in the same, while the local outcrops of older and
ounger beds are relatively unfossiliferous.

In my earlier papers I largely depended, for foraminiferal identifica-
ions, upon the opinions of the then official Palaeontologist in Calcutta;
nd I have since had to revise some of my conclusions after working out
hese forms myself, owing to the clarification in the meantime, through both
uttall's work and my own, of Indian foraminiferal designations, which were
n a very unsatisfactory state until 1925. Nuttall's description of the
pper Ranikot foraminifera of Sind was of great value to me in establishing
he presence of Ranikot beds in the Kohat district; after which I further
nlarged the list of systematically figured and described Ranikot forms to
uch an extent that, although only two foraminiferal species (both misiden-
ified) had been regarded as characterising the Ranikot formation in 1925,
he list of known Ranikot foraminifera is now as extensive as the corres-
onding lists of known Laki or Khirthar types. This has in turn facilitated
he recognition of Ranikot beds by other workers - notably oil geologists -
ho have paid the most attention to Nuttall's and my palaeontological papers.

After proving the existence of Upper Ranikot beds at Thal (although it
ad previously been supposed that they did not extend north of Sind) I
roved their extension over the whole of the Samana range. I also estab-

ished the existence of highly fossiliferous Lower Ranikot beds on that range. These latter beds, which I termed the Hangu Shales, still constitute the only really fossiliferous horizon known to exist in the Lower Ranikot. During recruiting work in the northern Punjab I also examined Pinfold's Chharat series, the stratigraphic position of which was uncertain until I approximately determined it by comparing their foraminiferal contents with those of the Eocene sequences in the Kohat district and Baluchistan.

Some years later, after retiring from the Army and graduating at Edinurgh University, I worked out Mr.Pinfold's foraminiferal collections from he Punjab Salt Range, determining the exact stratigraphy of the Eocene eds of that range, which had been completely misunderstood by previous orkers. I proved that the Eocene beds of the Salt Range belong to the anikot and Laki stages (although the existence on it of Ranikot beds had ust been categorically denied by a senior Officer of the Geol.Survey), nd that Khirthar beds do not exist on it (although most of the beds had een repeatedly referred to the Khirthar by another senior Officer of the eol.Survey). I further showed that the Ranikot and Laki sequences on that ange can each be subdivided into three distinct zones; that the latest anikot zone, named the Patala Shales by Pinfold and myself, is of later ge than any Ranikot zone yet found elsewhere; that the unconformity beween the Ranikot and the Laki is less marked on the Salt Range than elsehere; and that the latest Salt Range zone, known as the Bhadrar eds, is older than the latest Laki zone of the Kohat district, which is alled the Shekhan Limestone from its development in the Shekhan nullah a ew miles east of Kohat.

This elucidation of Salt Range Eocene stratigraphy directly concerns e Kohat district, since the western arm of the Salt Range forms the uth-eastern border of that district. It also (as explained later) helps date the first rising of the Salt Range axis; and so accounts for the errestrial interlude of the Lower Chharat - in the Kohat district as well in the northern Punjab - and the shifting of deeper waters from the east the west in Khirthar times, which is testified by the Eocene stratigraphy the Kohat district.

After working out the Eocene succession on the Salt Range, I revisited dia in 1935-1936 in order to complete my survey of the northern parts of e Kohat district, since most of the same had still never been visited or pped in detail by any geologist. I found on arrival that the Attock Oil mpany had advanced the mapping of the north-eastern corner of that disict from Tarkhobi to Gumbat, with some less accurate extensions further st. This portion is indicated on Text-figure 1. I roughly checked this rvey, replacing what I regarded as inaccurate with my own version, and was lowed, by courtesy of the Attock Oil Company, to incorporate the parts of eir map with which I agreed with my map of the remainder of the northern rts of the Kohat district, so as to form a complete supplement to Wynne's ps of the southern parts of that district.

During my survey of the northern half of the Kohat district, I did a rtain amount of work for the Attock Oil Company. This enabled me to visit eir principal sections in the Attock district, and to compare the sequences ere with those of the Kohat district. I also received Mr.Pinfold's colleoons from Waziristan, and paid a short visit to Waziristan myself. Alough, therefore, my survey of the Kohat district was single-handed, and I solely responsible for all details shown on the map (excepting the porion east of Gumbat), this later work to east and west of the Kohat district ed to a clearer understanding of the relationships of the Kohat sequence to equences on either side of it. In all cases, the palaeontological findings ere my own, since I was officiating as advisor to the Attock Oil Company hile examining their field sections and collected material.

After completing my map, I proceeded to Calcutta. I there offered my aper on the Eocene beds of the Salt Range to the Geol. Survey of ndia, and compared my collections from Kohat with their collections from ther parts of India. I also examined Sir Henry Hayden's Tibetan collec- ions, since the exact age of some of the later Tibetan beds had been in ispute for over thirty years. I found that some of these were packed with ypical Salt Range species, which I had just been describing in the Salt ange paper; and I was able, in a few minutes, to identify so many Ranikot pecies that the true age of some of the beds was fixed beyond dispute as pper Ranikot, while others pertained to the Laki. I published this fact s an Appendix to the Salt Range paper.

3. Topography.

The Kohat district is the most rugged portion of the North-West Frontier rovince. It is essentially mountainous, except to the south-east, where it is penetrated by a tongue-like extension of the plains of the Bunnu dis- rict to the south. Its south-eastern border is nevertheless mountainous, ing formed by the crest of the Punjab Salt Range, which rises some 4,000 et above the level of the adjoining plains, and swings to west and south ter crossing the Indus at Kalabagh.

From Latambar and Kharak northwards, the Kohat district assumes a pro- essively more mountainous aspect, the ridges becoming in general rather gher and closer packed, while they run approximately east to- st until they reach the Waziristan border, where they swing southwards ke the Salt Range. The highest hills of all are found along the northern rder of the Kohat district, beyond which lies the still more mountainous d lofty Tirah. An extension of the Tirah ranges, passing eastwards to erat, intervenes between the Kohat district and the plains of the Peshawar strict to the north-east. Thus about half of the Kohat district (i.e. the rtion lying to north and west of a line drawn from Latambar to Gumbat) nstitutes a broad salient, surrounded on three sides by tribal territory - ziristan on the south-west, Kurram on the north-west, and Tirah on the rth.

The town of Kohat, from which the district takes its name, is situated ar its northern border, where the most important and continuous of the rthern valleys, named the Miranzai, debouches to the east. Several other leys to east and west also debouch near Kohat, where a local patch of t country, about 10 or 12 miles in diameter, varies the otherwise mount- ous topography of the region. Kohat is connected with the Punjab to the t by some 40 miles of road and railway, across intervening ridges, to shalgarh on the Indus. To the west, both road and railway follow the anzai valley, which skirts the Tirah border as far as Thal at the extreme th-western limit of the district. Four frontiers meet at Thal, where tish territory forms a narrow triangular salient, with the Tirah to north-east, Kurram to north-west, and Waziristan to south-west. The Miranzai valley is here joined by the Kurram valley, which passes north-west through the Turi country (the inhabitants of which, being Shiah Mahommedans, usually side with the British against the Sunni Mahommedans by whom they are surrounded) to the Peiwar Kotal pass into Afghanistan. Thus the Miranzai valley forms the lower arm of one of the two main approaches into India from Kabul, the capital of Afghanistan; the other approach being through the Khaiber ~~KK~~ pass, which connects Kabut with Peshawar, some 40 miles to the north of Kohat.

It was via the Miranzai and Kurram valleys, and over the Peiwar Kotal pass, that Lord (then local Major-General) Roberts invaded Afghanistan in the winter of 1878-1879, while the main Afghan army was being engaged in the Khaiber pass; and it was at Thal, 40 years later, that General Dyer routed the Afghan chieftain Nadir Shah, who tried to invade India via the Miranzai valley during our domestic troubles in the Punjab.

Down the Kurram valley flows the Kurram river, passing through the point of the British salient at Thal, and then through the broader Waziristan salient to south of it, to enter British territory again near Bunnu, and finally to penetrate the Salt Range and join the Indus near Mianwali. Eastern tributaries of the lower portion of the Kurram river originate in the Kohat district, although most of the streams of the Kohat district flow in the opposite direction, to join the Indus above its junction with the Kurram. The watershed between streams flowing eastwards to the Indus, and westwards to the Kurram, may be represented by a line drawn from Kalabagh to Karbogha, and from Karbogha to Fort Lockhart. The upper portion of this line crosses the Miranzai valley near Kahe; and the level of the Miranzai valley rises steadily from Kohat (1,700 ft. above mean sea level) for about 40 miles to Kahe (3,200 ft. above m.s.l.), and then gradually descends for about 20 miles to Thal (2,500 ft. above m.s.l.). The country round Kohat and Thal is generally bare of vegetation except in the vicinity of streams; but in the highest parts of the valley, for about a dozen miles on either side of Kahe and for greater distances where the higher slopes are concerned) there is a considerable amount of vegetation, chiefly consisting of the dwarf palm (Mazarra) scrub. The hillsides here being wooded, it is less easy to trace the geological sequence than it is to east and west, where the principal stratigraphic features can often be recognised from considerable distances.

4. Tectonics.

A marked line of discordance coincides with much of the northern border of the Kohat district, where a well-defined fault flanks the lower parts of the Miranzai valley and continues beyond that valley to the Indus. The beginnings of this fault, to the west, are hard to trace, but they probably lie among a scattered collection of Mesozoic outcrops disposed round Thal, in the upper parts of the Miranzai valley. The fault becomes more distinct in the lower parts of the valley, but pursues an irregular course until it reaches the vicinity of Kohat, where it straightens out and strikes in a well defined and almost straight line to E.N.E. The amount of discordance connected with the fault also increases from west to east. Thus at Darsamand, 52 miles west of Kohat, the fault is not visible as such, but valleys to the north stand rather higher than the Miranzai valley, and the southern imbs of intervening anticlines are inclined to dip more steeply than the orthern limbs; at Hangu, 26 miles west of Kohat, the [redacted] fault is clearly een, although its course is irregular, and the greater steepness of the outhern limbs of Tirah anticlines is most marked; opposite Kohat itself, here the course of the fault straighten out, the southern limb of the djacent northern anticline becomes not only steep but reversed and overhrust, Mesozoic rocks to the north overriding increasingly younger Tertiry ones to the south, as the fault is traced eastwards. At the same time, he Afridi salient to the north of Kohat here stands about 800 feet higher han the adjoining portion of the Kohat basin.

It seems clear that rocks to north of the Miranzai valley overrode rocks o the south, and that the displacement was most pronounced to the east. hat the movement pivotted about Thal seems to be indicated by the grouping ound Thal of Mesozoic outcrops, among which the successive folds of Tertiry rocks sometimes terminate to the west, and beyond which their continuaions strike south-west and south through Waziristan and along the western order of the Bunnu district. The southern strike of Tertiary ranges west f the Kohat and Bunnu districts indicates that a thrust came from the west s well as from the north, and a southwards-striking fault in Waziristan estifies to the same fact; but the prevalent east-to-west strike of ranges ithin the Kohat district itself, and the very marked nature of the eastards-striking fault along most of its northern border, etc., show that the hrust from the north was the one which principally affected its orogeny. e influence of both thrusts nevertheless traverses the whole district, d is well seen along its south-eastern border; for there the Salt Range, fter crossing the Punjab from the east, swings round in a well-marked arch strike southwards. Mesozoic and even Palaeozoic rocks outcrop in the lt Range, the scarp faces of which - with associated fault at their base - e on its southern and eastern flanks (speaking generally, and discounting regularities) with corresponding dip-slopes to north and west. Thus the gle formed by the Salt Range outcrop along the south-eastern border of the hat district reflects, and seems obviously related to, the angle formed by e outcrops running east and south from Thal at its north-western extremity; r Mesozoic rocks are common both in the Tirah to north of the Kohat disict and in Waziristan to the west of it, although none (of any extent) apar within that district itself. One might roughly describe the Kohat cks as forming part of a knee-bend of Tertiary and post-Tertiary sediments unded by Mesozoic outcrops.

Lining the Mesozoic rocks in all cases (Salt Range in the south-east, d Afridi and Waziri mountains in the north and west respectively) appear nikot beds. As already stated, they were first shown to exist at Thal, en on the Samana, and afterwards on the Salt Range. I have since traced eir outcrops along most of the northern border of the Kohat district into ziristan, and also along the western borders of the Bunnu district, beyond ich a neglected outcrop which I long ago showed to exist in Zrind (29°55': °6') links them to the now classic Ranikot outcrops in Sind. When working rough Carter's collections at the British Museum (Nat.Hist.) I also found nikot fossils on slide No.P.30214 from the Valley of Kalat (29°2':66°39'). is affords a further connecting link between the Ranikot beds of Kohat and ose of Sind.

N.B. It is now obvious that Vredenburg's geological map of Baluchistan requires revision in the light of our greatly enhanced knowledge of Ranikot foraminifera. After probably referring too many beds to the

Ranikot in his earlier papers, Vredenburg reacted to excess in his later works and undoubtedly mapped a great deal as Laki which should have been shown as Ranikot. Unfortunately, nobody on the present Staff of the Geological Survey of India has sufficient knowledge of foraminifera to distinguish Eocene stages with certainty. Their inability to recognise the presence of Ranikot beds, even where the evidence is overwhelming, has been repeatedly shown by their attempts to deal with the Eocene formations of Waziristan, the Bunnu, Kohat, Peshawar and Attock districts, the Salt Range, and the Tibetan collections.

From the northern and western Mesozoic outcrops with their Ranikot ~~xxxx~~ fringes, to the south-eastern outcrops of the same kind, the entire central parts of the Kohat district are covered with later Eocene and post-Eocene beds. The numerous ridges which traverse this central region are mostly composed of outcrops either of anticlinal folds of hard Khirthar limestone, appearing between remnants of later beds, or of the separated limbs of such anticlines. Where the limbs are separated, there is often an alternation of anticlinal and synclinal valleys between successive ridges; these valleys being respectively occupied by Laki beds and post-Eocene ones. Nowhere that I have seen do Mesozoic, or even Ranikot, beds appear in the central parts of the Kohat district.

It is noticeable, as also apparently bearing upon the fact that the principal thrust came from the north, that the foldings of these Tertiary rocks are more numerous and pronounced in the northern parts of the Kohat district than in its southern parts; to south of which, again, come the plains which characterise most of the Bunnu and Mianwali districts. In the southern parts of the Kohat district, and more especially to the south-east, the synclinal valleys are broader than they are to the north and north-west; on the other hand, the outcropping anticlinal Khirthar ridges are generally narrower, and where their crests are excavated the resulting anticlinal valleys are narrower, and expose younger inlying rocks than are seen in the northern anticlinal valleys. Thus nothing definitely recognisable as older than the Lower Chharat is exposed in the southern parts of the district, although large exposures of Laki beds appear in the northern anticlinal valleys.

5. The Stratigraphic Succession.

Although such a well-marked change in the general orientation of hill ranges, from an eastwards to a southwards trend, takes place within this region, accompanied by faults showing corresponding thrusts from the north and west respectively, pivotting about Thal, it seems nevertheless clear that both to east and to south of Thal the orogenic features follow - and do not cross - the general lines of deposition of late Mesozoic and early Tertiary beds. Thus, to east of Thal, both lithological and faunistic facies are relatively constant along the axes of orogenic features, whose strike is in that direction; while changes occur fairly rapidly in the opposite direction - from north to south. Similarly, to south-west and south of Thal, the nature of deposits is remarkably constant from north to south along the general strike of the hill ranges, while it alters rapidly from west to east across that strike.

Well marked, therefore, as the change in orientation of axes is, and lear as the evidence seems to be of thrusting from two different directions t right angles to each other, it appears that these tectonic features simly follow, and accentuate, the pre-existing stratigraphic disposition. ence it cannot be solely the case, as suggested by Suess, that the orientaions of these lesser ranges, between the Himalayas and the Hindu Kush, reult from the efforts made by outlying parts of the major ranges to accomoate themselves to each other. Much apparently results from the course of revious marine sedimentation, which determined the lines of weakness along hich subsequent strains produced their main effects. So whether we regard he hill ranges of the North-West Frontier Province as outlying portions f the Hindu Kush or of the Himalayas, their derivation, in course as in bstance, seems mainly attributable to the disposition of later marine aters in that region.

Since the Kohat district lies in the pivotal area, covering most of the ee-bend where orientations change from an east-to-west strike to a north-south one, it might be expected to afford the best evidence for correlatg eastern beds with southern ones; and this is in effect the case. Thus has not been easy, hitherto, to determine the relationships of the umal Sandstone and Chikkim beds of the Himalayan region to the Parh beds d Pab sandstones of Baluchistan; but I have found what I regard as transional links in the Kohat district. The Giumal Sandstone, capped by a fosliferous Gault horizon, seems to be a reduced equivalent of the "main ndstone series" of the Samana sequence, which is also capped by a fossilirous Gault horizon; while the abrupt transition in the east to the lightloured Chikkim Limestone, which follows the Gault, is matched by the abpt transition on the Samana to the "lithographic limestone" which succeeds e Gault in that section. Traced westwards from the Samana, however, these ds change in aspect, particularly near Thal, assuming facies much more ke those of Baluchistan; for the "main sandstone series" gives place to ales, while the "lithographic limestone" locally exhibits collections of lemnites at its base, and develops - especially in its lower parts - a cies much resembling the "Parh" beds of Baluchistan. Similarly the Hangu ndstone locally gives place, at Thal, to a great thickness (over 1,000 et) of sandstones which may well correspond with the "Pab" sandstones of e south.

It is noticeable that the greatest known developments of Lower Ranikot ds are found in the western parts of the Kohat district and in Sind, ile in both these regions the Upper Ranikot terminates with the Khairabad mestone or its equivalents. Further to the east, in northern latitudes, e Lower Ranikot tends to disappear, but very late Ranikot elements (the tala Shales) succeed the Khairabad Limestone.

With the advent of the Laki, however, the northern deposits adopted atures of their own, even in their western parts, which are worth noting. e Laki, which is well developed both in Sind and Baluchistan, is very orly developed indeed in the western parts of the Kohat district, although rgely developed to the east. Thus very early Laki deposits are found on e Salt Range (and therefore on the south-eastern border of the Kohat disict) which are probably earlier than anything hitherto found in Sind or luchistan, and would seem to represent some of the elements whose absence indicated by the "Basal Laki Laterite" of Nuttall's southern sequence. e Sakesar Limestone of the Salt Range may be equivalent to the Dunghan mestone of Baluchistan, and the Bhadrar beds of the Salt Range to the Metg Shales of Sind; but the facies are rather different. These beds are al-o best developed to the east of the Indus, in the north. The Shekhan Lime-tone of northern latitudes is almost certainly equivalent to Nuttall's Laki Limestone" of Sind (an unfortunate term, since it is by no means the nly limestone found in the Laki); but it is the only Laki element found far o the west, as well as to the east, in the north. Even the Shekhan Lime-tone becomes rapidly reduced to the west, however, and finally disappears efore reaching the Waziristan border.

This progressive reduction and early disappearance of Laki beds to the est is a remarkable fact, whose significance should not be overlooked. I ound no beds of Laki age in northern Waziristan, although both Ranikot and hirthar beds are present there. Nor do any Laki fossils appear in Mr.Pin-old's collections from southern Waziristan, although Ranikot and Khirthar ossils abound in them. Statements by Dr.A.M.Heron, the present Director of he Geological Survey of India, to the effect that Dr.Coulson found Laki eds in Waziristan, are totally unsupported by fossil evidence - as he dmitted when I asked for such evidence. Indeed, he made it clear that Dr. oulson depended solely upon the lithological resemblance of certain Wazir-stan beds to ones in the Sherani country which Vredenburg had tentatively ssigned to the Laki. But even the latter were unfossiliferous; and Vreden-urg had correlated them on lithological grounds with ones still further outh, in Baluchistan, which he had referred to the Laki, but which I have ince shown to include Ranikot beds.

The fact is that (as Vredenburg himself pointed out) lithologically sim-lar beds recur at many levels on the north-west frontier of India, from ower Cretaceous to later Tertiary times. So the case, as known at present, s that Laki beds are best developed in the eastern parts of the Kohat dis-rict, and on the Potwar plateau to the east of it, and progressively dimin-sh to the west; the last remnants of the latest Laki beds being found a few iles east of Thal. Laki beds do not exist in northern Waziristan; and they ave not yet been shown to exist either in southern Waziristan or in the erani country still further south, although they undoubtedly exist in Bal-chistan. There is every reason for concluding, on the present state of the idence, that the Afghan coast approached India at the close of the Ranikot, robably owing to the emergence of northern Afghanistan, with relation to dia, at that time. This would have continued the previous emergence, in ate Cretaceous times, which freed northern Afghanistan to a large extent om the waters of the great Cenomanian transgression which had temporarily vered the whole of it.

In order to appreciate the effects of this further (latest Ranikot or asal Laki) emergence of northern Afghanistan upon sedimentation in the Ko-t district, it is necessary to recall the general distribution of the Ran-ot sea.

The Indian sea of Paleocene times had apparently become segregated from ropean waters, owing to the breaking up of Tethys at the close of the Mes-oic. I infer this segregation from the marked distinction of Indian Rani-t foraminifera from the contemporary foraminifera of Europe. The Indian ecies which Vredenburg and Nuttall identified with _N.planulatus_ is really ite distinct from the latter, and I redescribed it as _N.nuttalli_. It is e central member of a remarkable group of forms which has no parallel in ropean deposits, and includes the singular genus _Miscellanea_; and it is companied by other well marked species and even genera which have also not t been found in Europe (e.g. _Lockhartia haimei_, _Sakesaria cotteri_, _Dictyo-noides flemingi_, _Polylepidina punjabensis_ etc.).

Segregation alone seems able to account for this marked distinction of anikot forms from European ones; for there is no great difference in longtude between some Upper Ranikot deposits and those of Europe, and the disinction between Indian and European faunas becomes rapidly less after the anikot.

At the same time, it is clear that segregation could not have commenced efore the Danian; for Vredenburg found the characteristic Upper Maestrichtan species Omphalocyclus macropora in many parts of Baluchistan from Las ela in the south to the Mari hills in the north, I myself recently found t in Kohat deposits, and both Vredenburg and Douvillé recorded its appeard in collections from Tibet. It is therefore clear that direct communiation between western Europe, India and Tibet must have continued until ate Maestrichtean times.

Segregation nevertheless existed at the commencement of the Tertiary. e extent of the Lower Ranikot sea is not yet known, owing to the enerally unfossiliferous nature of Lower Ranikot beds, and their often bviously fluviatile character; but the presence of Ostrea and Cardita eaumonti in certain basal Tertiary beds of southern Afghanistan and Sind ndicate marine conditions there, and the discovery of richly fossiliferous ower Ranikot beds (the Hangu Shales) in the Kohat district indicates that marine estuary must have penetrated as far north as the Samana range and there urned eastwards for at least 40 to 50 miles.

The course of the Upper Ranikot sea is much more easy to trace, owing the highly fossiliferous nature of most of its sediments. The Ranikot ea attained its maximum distribution in early Upper Ranikot times. I have own elsewhere that its deposits extend from Shamshir-i-Quli (33°30':47°10') western Persia to Kampa Dzong (28°2':88°30') in Tibet. It apparently vered a great area that is now land in southern Persia, southern Afghanstan, western Baluchistan and Sind, while a singularly long and relatively stuary passed eastwards across northern Baluchistan, turned northwards ong the line of what are now Waziristan and the North-West Frontier Provice to about 50 miles south of Kabul, where it again turned east, passing er the Kohat district, much of the Tirah, and much of the Peshawar, Atck, Rawalpindi and Jhelum districts, towards the present north-west Himayas which apparently crossed in the vicinity of Singhe La in Zanskar. It en passed south-east and east, skirted the southern borders of the Manarowar Lakes, and reached as far (at least) as Kampa Dzong south of the ahmaputra. Text-figure 2 indicates the Indian portion the Upper Ranikot sea, as reconstructed by myself from the present state the evidence as to the distributions of Upper Ranikot outcrops.

It will be seen that the Kohat district covers most of the western half a sector of the Upper Ranikot sea which extended from Waziristan in the st to what is now the Pir Panjal range in the east. Since the Potwar ateau covers most of the eastern half of this sector, I propose to term e whole sector the "Kohat-Potwar basin". The western end of the basin s connected via Waziristan and the Sherani country etc. with the open sea the south, while an extension from its eastern end crossed the present malayan axis and continued to Tibet.

It will therefore be realised that the further emergence of Afghanistan the commencement of Laki times, which has already been mentioned, both splaced and narrowed the communications of the Kohat-Potwar basin with e open sea; an important fact when studying the geological history of his area. This emergence may well have been correlated with other earth ovements leading to the destruction of the barrier between Indian and Eurpean waters, for the fauna of the Laki witnesses to an increasing infusion f European species of foraminifera, in the Kohat district as elsewhere.

Other marked developments during the Laki are evidenced to the east of he Kohat district rather than within it; for it is clear, from the disturbnce shown by Laki sediments along the flank of the Pir Panjal range, and rom the displacements northwards and outwards of Laki sediments in Kashmir, ras and Ladak, that the north-west Himalayan axis began to rise in Laki imes. That it finally severed connections between the Kohat-Potwar basin nd its trans-Himalayan extension by the end of Laki times, is indicated by he absence of any known marine deposits of later age in the trans-Himalayan region. y reconstruction of Indian marine geography in early Laki times is shown by ext-figure 3. It will be noted that the main evidences of disturbance ocur at the two ends of the Kohat-Potwar basin, which is shortened and broadned as a consequence. The trans-Himalayan extension of the earlier sea is isplaced only at its junction with that basin; the Kampa Dzong Laki beds, t the upper end of that extension, succeed the Ranikot without such dislacement.

Soon after the Himalayan axis began to emerge, the Salt Range axis seems lso to have commenced rising. This event, although less interesting than he initial rise of the Himalayan system, had a more direct effect upon tratigraphy within the Kohat district itself, and is also partially witessed within the district since it contains the western limb of the Salt ange. Thus although the Eocene sea (which shallowed after Khairabad Limetone times, and remained shallow during the succeeding uppermost Ranikot atala Shale, and lowest Laki Nammal Shale, periods) deepened over the Salt ange area during the Sakesar Limestone phase, it shallowed again - and nally - while the Bhadrar beds of Upper Laki age were being deposited. later beds of a marine nature are found on the Salt Range, nor do any irthar marine beds appear even in its vicinity. On the contrary, later arine beds are progressively removed from its vicinity; Khirthar ones being ound further from it than latest Laki ones, and the later Khirthar further han the earlier. This seems to indicate that the Salt Range axis also rose some extent during later Laki times.

As might be expected from such an event, after the displacement and narowing of communications with the southern sea, desiccation ensued of the emaining marine contents of the Kohat-Potwar basin. It is probable that a ntinuation of the western end of the young Salt Range axis formed a bar or oal across what remained of communications with the south, while the waters of the basin retreated northwards and north-westwards from the Salt Range egion. It is there - <u>i.e.</u> to north-west of the Salt Range - that the main psum and Salt deposits of unmistakeable Tertiary age are found; and it was obably there, opposite what remained of communications with the south, at periodic fresh incursions of marine waters entered the Kohat-Potwar asin, to add their salt contents to what had already been concentrated out, ch as the Karaboghaz Gulf of the Caspian Sea is becoming increasingly more line at the present day.

Following upon the latest Laki phase of this region came the lacustrine fluviatile Lower Chharat phase, the circumstances leading to which I beeve are here explained for the first time. Since no other geologist has ncentrated as I have on the study of the Eocene foraminifera of this reon, no other has been able to distinguish both the stages and the zones f the Eocene represented by the various nummulitic deposits of these parts. ince other geologists have not been able to distinguish confidently between ne remains of different Eocene phases, they have generally supposed that ecause Eocene beds appear both on the Himalayas and on the Salt Range, both imalayas and Salt Range rose after the Eocene; whereas I hold that they ose during the Eocene, and within the same stage of the Eocene, although ne one movement began earlier in that stage than the other.

It now seems for the first time possible, as a result of my work on the posits of the Kohat-Potwar basin, to understand why desiccation followed e Laki in that region, and why a fluviatile interlude succeeded the desic- ation. All the evidence seems to be consistent. The distribution of the cene sea at the close of Laki times is indicated by Text-figure 4.

The Kohat-Potwar basin seems to have remained much the same, as to gen- al shape, during Lower Chharat (Lower Khirthar) times as it had been during e Shekhan Limestone period (the latest Laki phase). This is well seen in e Kohat district, where Lower Chharat beds become progressively thinner d coarser in type towards the west, just as the underlying Shekhan Lime- one ones become thinner and shallower in nature towards the west. Indeed, th sets of beds finally terminate along much the same line, for the last agments of Lower Chharat conglomerates were seen by me at Thal, only a few les beyond the last traces of Shekhan Limestone deposits; and the Lower harat, like the Laki, was not found by me in northern Waziristan, where [redacted] Upper Chharat (Middle Khirthar) marine beds erlap directly onto the Ranikot. This must indicate the shape of the bas- itself, and cannot be due to subsequent denudation. The parallel changes type towards the west of two successive formations, and their similar ding at about the same meridian, give what I regard as unequivocal evid- ce of the shallowing of the basin [redacted] to the west.

I also found that the Eocene succession west of Saidgi, on the Waziri- an border W.S.W. of Bunnu, shows Middle Khirthar beds immediately overlap- ng onto Upper Ranikot ones, the Lower Chharat being absent as well as the ki, just as both are absent opposite Thal over 30 miles to the north. We ve thus good reason for concluding that the Kohat-Potwar basin had greatly duced connections with the south during Laki times.

That some such connection did survive, however, even to the end of Laki nes, is indicated by the presence (long ago noted by Wynne, and recently nfirmed by Pinfold and myself) of small marine molluscs in the lowest lev- s of the Lower Chharat beds about 2 miles W.S.W. of Barbara Banda village $3^{\circ}16':71^{\circ}6'$). I found that the Nummulites, which are also mentioned by ne, are not <u>in situ</u>. They are typical Upper Chharat forms, and occur in nestone masses which have obviously slipped down from the overlying Upper arat beds. But the molluscs have every appearance of being <u>in situ</u>. hing like them exists at any higher level; and their matrix is of Lower arat type, in perfect keeping with the unfossiliferous Lower Chharat lay- among which they are found. Dr.L.R.Cox of the British Museum (Nat.Hist.) since described these molluscs, so far as their state of preservation itted. Mr.E.R.Gee of the Geol.Survey of India has reported finding mar- molluscs at a similar level near Bahadur Khel ($33^{\circ}11':70^{\circ}57\frac{1}{2}'$) and Jatta $^{\circ}20':71^{\circ}17'$), but his forms have not yet been figured or described. It worth noting that these latter exposures are slightly to south-west and th-east respectively of Barbara Banda, and may indicate the line of a ll residual marine connection.

Although the shape of the Kohat-Potwar basin does not seem to have alt-red between latest Laki times and Lower Chharat ones, there is good evid-nce that it changed to some extent with the advent of the Upper Chharat arine phase. For it seems certain, not only that the land sank at the lose of Lower Chharat times, but that the basin itself acquired a degree f tilt to the west when it did so. Thus the immediately succeeding Kohat hales are most calcareous in type and most fossiliferous towards the west, nd least so towards the east; the Nummulite Shale, which follows the Kohat hale, is not really a shale but a limestone to the west of Kohat, and is ost truly a shale to the east of the Indus. The succeeding massive forma-ions, which I propose to call the Kohat Limestones, are not found at all the east, but only appear in the Kohat district.

These facts, together with the fact that the Upper Chharat and succeed-ng beds transgress far over Waziristan to the west, clearly indicate, in y opinion, that the shape of the basin of deposition changed at the close f Lower Chharat times. Not only must the land have sunk as a whole (as ne reappearance of marine beds testifies) but the basin must have acquired tilt to the west, making its eastern portion the shallower part instead f remaining the deeper as it had been during the Laki and Lower Chharat. do not agree that a large amount of later Eocene beds has been removed rom the eastern parts of the basin, by denudation prior to the deposition f Murree beds there (as some have suggested); because the peculiarly shaley ature of the Nummulite Shale (which derives its designation from its east-rn aspect) in the Chharat region, indicates that the sea was actually shal-ower there than it was to the west. The significance of the increasingly lcareous nature of the same bed, as traced to the west, is no more to be istaken than the significance of evidence of an opposite kind in regard to ne underlying Lower Chharat and Laki beds. The basin had acquired a tilt the opposite direction; and the fact that no fragments of later beds rvive to the east, even in faulted regions, although they are so well de-eloped to the west, suggests that the tilting was progressive, and contin-es during the later phases of the Khirthar.

If we look further to the east, beyond the Chharat region, we find that ne Nummulite Shale itself is either missing or else represented only by nbiguous fragments (Wadia's "Jokan" beds) whose very nature indicates fur-her modification in the nature of sedimentation.

This tilting of the basin need not indicate a tilting of the land as a nole. I suspect that it was due to further emergence of the Himalayan and lt Range axes, which would lead to the relative shallowing of the eastern d south-eastern parts of the basin, even though the land in general [redacted] nk in epeirogenic fashion. In other words, although Afghanistan sank ain to some extent under the sea, it is not necessary to suppose that it d so differentially, in regard to north-west India, its relations to ich I think probably remained unchanged.

The Kohat Limestones (as I propose to call them) are of post-Chharat e, but conformably succeed the Nummulite Shale (the latest Chharat member); ne transition being well seen in the Shekhan nullah section near Kohat, ere the Nummulite Shale is still rather imperfectly indurated and litho-gically distinct from its successors. Further to the west, the represent-ives of the Nummulite Shale are really limestones, and only distinguish-le from their successors by their rather more flaggy nature.

The Kohat Limestones are less [redacted] fossiliferous in general (except tords the top) than the Nummulite Shale; but they apparently belong to the me zone as the latter and the Kohat Shale, namely, the Middle Khirthar.

Succeeding the Eocene marine beds, from Chharat in the east to Waziris-n in the west, derived fossils from those beds often appear in the lower vels of the superimposed later Tertiary fluviatile sediments (which are Murree type round Kohat and to east of Kohat, but give place to Kamlials out the meridian of Bahadur Khel, and are of Chinji age near Thal and gri age in northern Waziristan). The layers with derived fossils constit-e Pinfold's "Fateh Jang" zone to the east; but it is simply a contact zone erever found, being dated according to the matrix locally containing the ssils.

Between Hangu and Sarozai, however, I found fragments of true marine ales succeeding the Kohat Limestones, and intervening between them and e fluviatile beds. The matrix of these shales was distinct from that of e later Tertiary sediments; and the fauna of the shales was also obviously t derived from any lower beds, since it was distinct in type and indicated later horizon. I found that it corresponded with the fauna which I col-cted from the uppermost levels of the Khirthar section at Spintangi, in rthern Baluchistan, which is the type area for the Spintangi, or Upper irthar, beds which Vredenburg cited as being well represented Baluchistan and Sind.

These shales, which are the latest Eocene beds found by me in the Kohat strict, are the only representatives of the Upper Khirthar that have been scovered so far north. It is worth noting that they appear in what had obably been the deepest parts of the Kohat-Potwar basin in later Khirthar mes. It seems significant that I found an Ostracod of the genus <u>Cythereis</u> them, indicating a last return to estuarine conditions before the sea nally abandoned this region.

I now propose to describe in detail the succession of beds which has en outlined above in more general fashion. I will commence with the later sozoic formations, as introducing the Eocene ones.

The Upper Jurassic (= later Kioto) Limestone.

The lowest Mesozoic formation which I have continuously traced in the hat district is the one which I called the Samana Suk Limestone, in my scription of the Samana sequence. It is the most constant of all local rmations, about 500 feet thick on the Samana itself, and consists of a rk grey crystalline limestone, generally unfossiliferous, but locally owing traces of Cephalopods, Brachiopods and Crinoids. Its uppermost lay-s sometimes assume a brecciated aspect (very like that of the Hangu Brec-a) and in other places are distinctly oolitic. It corresponds, both in pe and in stratigraphic position, with a massive limestone, with a massive nestone, 500 to 1600 feet thick in the Attack and Hazara districts, which Cotter identified with Hayden's Kioto Limestone of Spiti and Kashmir, ich is sometimes over 2,000 feet thick. At the same time, since Cotter ys that the Kioto Limestone ranges from the Noric to the Callovian, it uld seem that the Samana Suk Limestone of Kohat can only correspond with s uppermost levels; for I found a Brachiopod which Miss H.Muir Wood regard as a Callovian - possibly Bathonian - type in shales immediately underly-g it near the Samana Suk. The base of this limestone is not seen in more stern exposures; but its thickness cannot be less than 700 to 800 feet at rsamand, to judge from the extent of its outcrop there. It appears as e hard dome-shaped core of conical mountains like Darsamand and Kadimak, ter sediments being wrapped round it like the successive coats of an oni-.

The Neocomian Belemnite Bed (= Spiti Shales).

Following the above-mentioned limestone on the Samana Range come about to 50 feet of glauconitic sandstone, packed with Belemnites. Since an monite which I found at this level near Thal was regarded by Dr.L.F.Spath indicating a lowest Hauterivian age, this bed was treated in my Samana per as being a Neocomian formation. It may thus be correlated with the iti Shales, which range from the Argovian to the Valanginian according to tter, and succeed the Kioto Limestone in Spiti, Hazara etc.

This bed varies a good deal in nature when traced to the west, but al-ys seems to contain an abundance of Belemnites. At Darsamand it consists from 20 to 30 feet of olive and red shales, full of Belemnites. On the uth-western slopes of Kadimak mountain, near Thal, it is no longer dis-nguishable as a separate lithological unit, but is represented by numer-s Belemnites near the base of a great thickness of otherwise unfossilifer-s olive shales which succeed the Samana Suk (upper Kioto) Limestone.

The Lower Cretaceous Sandstones (= Giumal Sandstone).

These are represented, in the Samana section, by about 700 feet of artzitix sandstones, with shale partings, which I called the Main Sand-one Series in my description of that section. I showed that, being capped a Gault horizon, this formation probably corresponds with the Giumal ndstone of Spiti and Hazara, the Giumals of Hazara being similarly capped a Gault horizon. Dr.Cotter, who went more fully into the matter soon terwards, came to the same conclusion. It is clear, however, that the ndstone is much more largely developed on the Samana than to the east.

To the west of the Samana, this bed also changes its character. At Dar-nand, the formation is still a quartzitic sandstone, up to 500 feet in ickness; but in the section on the south-western flank of Kadimak mountain Thal it is seen to consist of some 550 feet of shales only, of which the wer 450 feet are olive shales (full of Belemnites at their base), and the per 100 feet are pinkish to purplish shales and light-coloured bands with ant remains.

The Gault Band.

This is a highly fossiliferous, calcareous and phosphatic grit, only out 5 or 6 feet in thickness, which caps the Main Sandstone Series on the nana. According to Dr.Spath, its fauna (which includes many specimens of uvilleiceras mamillatum Schlotheim) indicates a Middle to Upper Albian e. A very similar assemblage (also including Douvilleiceras mamillatum) pears in the Gault of Hazara, immediately above the Giumal Sandstone.

During my recent visit to the Kohat district I noted the presence of emnites in some exposures of this bed, and found that the bed itself does continue much to the west of the Samana. Thus I could not find it in

ie Darsamand section, its place being taken by a rather coarse conglomer-
ie, 2 to 3 feet thick, containing large limestone pebbles and occasional
lemnites. This conglomerate continues to the western limits of the Kohat
strict, being well represented at the corresponding level in the south-
stern Kadimak section, where it is even coarser, some boulders in it
asuring 2 feet in diameter. It is there from 3 to 8 feet thick, and
ill contains occasional Belemnites.

The Upper Cretaceous Limestones (= Chikkim Limestone = ? Parh Beds).

On the Samana, as to the east, there is an abrupt transition from Gium-Sandstones and Gault to succeeding fine-grained limestones. I called e latter Lithographic Limestones, in the Samana paper, and remarked on e unconformity between them and the underlying Gault grits, pointing out w the unconformity was emphasised by the presence of derived Gault fos-ls in the lower levels of the limestones. Probably the coarse conglomer-e which replaces the Gault to the west gives further evidence of this conformity.

I think that these limestones can - as already suggested in the Samana per - be correlated with the Chikkim Limestone of the Himalayan region, ich similarly succeeds the Giumal Sandstone. The formation is doubtless Upper Cretaceous age, since it is both pre-Ranikot and post-Albian. ne parts of these limestones show no traces of fossils on sectioning; but hers are full of minute foraminifera, and resemble the Chalk of western rope.

These limestones, locally divided into two masses separated by sandstones i shales in the western parts of the Samana ~~x~~ range, are still recognisable Darsamand, where they consist of some 200 to 300 feet of limestones, which e sometimes lithographic in type like the Samana limestones, but at others velop a pink and white cherty facies recalling the Parh beds of Baluchis-n.

In the south-western Kadimak section the change becomes very marked, and is difficult to know where to draw the line between this formation and e next one. I provisionally allot the following beds of that section to s group, taking them in ascending series:

(a) Purple and green shales, with white calcareous bands, often assuming resemblance to Parh beds, and locally containing many Belemnites near their base .... 320 ft.

(b) Massive light-coloured sandstone, with spongy grit on top (dun-coloured in other sections, and sometimes locally replaced by a conglomerate).................. 100 ft.

(c) Purple and green shales (locally containing some oolitic and other limestone bands or lenticles) .... 100 ft.

se three sections may correspond, respectively, with beds 5, 6 and 7 of e Samana sequence.

Although these beds seem to be continuous with the Lithographic ~~xxxxx~~ nestones of the Samana section, and so may be correlated through them with he Chikkim Limestone of the Himalayas, their facies, especially in their ower portions, resembles that of the Parh beds of Baluchistan, which inci- entally show a similar abundance of Belemnites at or near their base. hus the Kohat district deposits help to correlate the Himalayan Cretaceous equence with that of Baluchistan.

It should be noted, however, that the above-described Mesozoic sequence n the northern and north-western parts of the Kohat district is fuller han the Mesozoic sequence on the Salt Range, the western limb of which orms the south-eastern border of the Kohat district. Only the lower parts f the Lower Cretaceous beds, with the Belemnite bed and the underlying urassic (Kioto) limestone, are found on the western end of that range. he last of the Cretaceous beds seems to disappear in the Chhidru area, and he last of the Jurassic beds disappear near the Nilawan gorge. Thus the ucceeding Eocene beds of the Salt Range area overlap onto an increasingly lder Mesozoic and Palaeozoic surface when traced to the east.

The Hangu Sandstone.

This is the lowest formation which I referred to the Eocene in my de- cription of the Samana sequence; and if rightly so referred, it is the ldest known Eocene formation in the Kohat district. It consists, on the mana, of about 140 feet of white quartzitic sandstones, variously banded mottled by iron oxides, and is indistinguishable in appearance from derlying Cretaceous sandstones of the same section. My only reason for signing it to the Lower Ranikot is that its upper levels (which locally ntain many small angular blocks of limestone) become very calcareous, and ss with apparent conformity into the highly fossiliferous Hangu Shales of doubted early Ranikot age. There is thus no reason for postulating an conformity between the Hangu Shales and this bed, while fairly good reas- exists for suspecting an unconformity between this bed and the underly- g Lithographic Limestones.

My recent more general survey of the Kohat district produced no evidence nflicting with this opinion; although it showed that this bed, like its edecessors, changes greatly in the vicinity of Thal. It does not, howev- , change in the same gradual way as its undoubted Mesozoic predecessors. the Darsamand section it is practically unaltered, true to type in every spect, and about 100 feet thick. Even on the eastern and south-eastern opes of Kadimak mountain it is still perfectly recognisable, and from 100 150 feet in thickness. It still contains - there, as at Darsamand and the Samana - local accumulations of small limestone blocks embedded in s upper surface, which is calcareous and succeeded by a small quantity of ssiliferous Hangu Shales.

On the southern and south-western slopes of Kadimak mountain, however, e succession changes with astonishing rapidity. The formation is first en, in an incomplete section, to be represented by a considerable thick- ss of dun-coloured sandstones and grits with olive shale partings, which e succeeded by 400 feet of what are probably olive shales but are mostly ncealed by detritus, the whole being capped by 55 to 60 feet of Lockhart nestone. These sandstones and grits contain small foraminifera of Rani- t types.

On the south-western slopes of the mountain the change is even more rked. I have already referred beds (a) to (c) of that section to the

pper Cretaceous, and correlated them with the Lithographic Limestones of
ie Samana sequence; the following immediately succeeding beds would in
iat case represent the continuation of the Hangu Sandstone:

(d) Brown, black-weathering sandstone .... 30 ft.

(e) Coarse conglomerate, with very ferruginous matrix (some of the pebbles in it contain Omphalocyclus macropora Lamarck) .... 30 ft.

(f) Brown, black-weathering sandstones, with subordinate green shales .... 1,000 ft.

(g) Olive shales, with one or two subordinate bands of black-weathering sandstones .... 230 ft.

(h) Fine conglomerate, with Orbitolina and fragments of Belemnites, Corals, Crinoids, Echinoids, pebbles of oolitic and other limestones and of black-weathering rocks etc. .... 2 ft.

After this come shales etc. with Upper Ranikot fossils. The sequence
so unfamiliar in type that it suggests faulting; but the presence of
phalocyclus macropora in pebbles of bed (e) indicates that that bed must
of post-Maestrichtean age and is probably Tertiary. The enormous thick-
ss of sandstones in bed (f) has no place in the local lower sequence; and
en the Orbitolina in bed (h) seem foreign to the local sequence (like
ny of its other contents) and were probably derived from beds to north or
rth-west of Thal. The same applies to the Omphalocyclus, which I have
t yet seen in any sections of local rocks found in situ.

Although, therefore, the area is rather a faulted one, I cannot regard
e beds of the south-western Kadimak section as belonging to a lower por-
on of the local sequence. It seems necessary to accept the fact that the
al region was one of abnormal deposition. Three miles south of Kadimak,
Kurram Picquet hill just south of Thal Fort, there are over 700 feet of
ack-weathering sandstones and green to brown shales, largely fossilifer-
s and of Ranikot age, underlying more than 600 feet of shales capped by
pical Upper Ranikot beds. These sandstones I long ago referred to the
wer Ranikot. It seems to me that the successive conglomerates in the
al region, and the great accumulation of sandstones - possibly contempor-
y with the Pab sandstones of Baluchistan - probably indicate that a north-
n river discharged its contents in this region. A noticeable feature of
e Kadimak sandstones is that they contain a considerable number of well-
unded quartz grains. These probably came from northern Afghanistan, which
y have had little vegetation and developed desert conditions after emerg-
g from the Upper Cretaceous sea.

I therefore provisionally regard the great thickness of unfossiliferous
ndstones of the south-western Kadimak section as representing a delta, of
ich the more fossiliferous sandstones exposed at Kurram Picquet etc. re-
esent the seaward aspect. Since this river probably followed a course
t far removed from that of the present Kurram river, I propose to refer
it as the (still rather hypothetical) proto-Kurram river (see Text-fig-
e 2).

A southern (equally hypothetical) river which I postulate on grounds ich cannot be detailed here, I will refer to as the proto-Sarasvati river. th rivers, if they existed as I suspect, came into prominence in Lower nikot times, although both began to take form in the Cretaceous.

The Hangu Shale.

I recently traced this bed from Bar Jangal village, a little north-east the Samana, to the south-eastern slopes of Kadimak mountain at Thal. It never more than a few feet in thickness (2 to 20 feet on the Samana); t it seldom fails to appear, with some of its characteristic fossils, be-een the Hangu Sandstone and the Lockhart Limestone wherever the junction those two formations is seen. The fauna of this bed mainly consists of lluscs, which have been described by Dr.L.R.Cox; while its corals were alt with by the late Prof.J.W.Gregory. It contains few foraminifera; but found at least one foraminiferal species of stratigraphic value in it, mely Lockhartia haimei, a typical Ranikot form which has never yet been en in any but Ranikot sediments.

As might be expected, this very narrow bed disappears as soon as the ture of the local sequence changes; it has only, so far, been found in the ranzai valley. On the other hand, its persistence along nearly 40 miles the northern border of that valley indicates that the valley itself must proximately coincide with the shore-line of the estuary in which these les were deposited. I therefore conclude that the early Ranikot sea, a rrow tongue of which may more or less intermittently have reached as far th as Thal, probably managed, when the land began to sink later in Lower ikot times, to cross the mouth of the proto-Kurram river and extend east-ds towards Kohat along the bed of the preceding Cretaceous sea, whose rse in that direction is indicated by the continuity in it of preceding llow-water formations (such as the Belemnite bed, the Gault band, and Hangu Sandstone itself).

The Lockhart Limestone.

This limestone is the most massive one pertaining to the Ranikot in the at district. Where seen in its entirety, as below Fort Lockhart on the ana range, it is 200 feet thick. Portions of it (base not seen) outcrop ermittently along the fault line in the lower parts of the Miranzai valle east of the Samana, to about the meridian of Kohat itself; after which increasing degree of overthrust conceals it from view in the north. At khobi, however, more than a hundred feet of it are exposed; and its con-uation beyond the Indus seems to be represented by 80 feet of Ranikot estone near the base of the Ranikot sequence on the Kalachitta range, 11 es north of Domel.

To west of the Samana range, this limestone can be continuously traced as as Kadimak mountain, where it last appears as a mass 55 feet thick, dip-60° to the south, on the southern flank of that mountain. There, as at Lockhart, its uppermost layers are cherty and full of foraminifera.

The upper portions of this limestone are certainly of Upper Ranikot age; I think the greater part of it probably corresponds with the Dhak Pass and succeeding Khairabad Limestone of the Salt Range sequence, both of h I would refer to the Upper Ranikot. I think, however, that the Hangu ale fauna indicates an older horizon than that of the Dhak Pass beds; and regard the lower parts of the Lockhart Limestone, where found in immediate quence to the Hangu Shale, as being probably of Lower Ranikot age.

At Thal, the Lockhart Limestone terminates rather abruptly. Although s actual end is hidden under later beds, it is still at least 55 feet ick when last seen, and yet makes no reappearance a few miles west and uth where later Mesozoic and early Eocene rocks again outcrop. This may due to the disturbing influence of the proto-Kurram river. Upper Ranikot ds to west are predominantly shaley and unfossiliferous; although some llow calcareous layers, and certain more sandy ones, are highly fossilifer s. The presence of numerous corals in some of these layers indicates clear ter. I suspect that rainfall was small, and that occasional long periods complete drought tended to clear the waters and allow of temporary invasns by rich marine faunas. The Upper Ranikot beds of Waziristan, so far as saw them, were of this nature, consisting of considerable thicknesses of fossiliferous shales, with occasional highly fossiliferous layers in beeen. The sea was apparently less deep in Waziristan than in the Kohattwar basin, and fluviatile influences were more marked.

The Khairabad Limestone.

The Khairabad Limestone of the Salt Range - which I correlate with the per portions of the Lockhart Limestone - is a nodular formation and much ss massive than the Lockhart Limestone. Its overlap onto a progressively der surface indicates that the border of the Ranikot sea cannot have passmuch beyond the limits of the present Salt Range; and as Sir E.Pascoe has narked, no traces of Eocene beds are associated with the outcrops of older ks which occur only 25 miles south of the Salt Range. Conditions here inate shallower water than on the Samana; but there is not the same evidence the presence of a river that one finds in the Thal region.

As already remarked, the Ranikot sea seems to have reached its maximum elopment in Khairabad Limestone times. The collections from Shamshir-ii in western Persia, and from Kampa Dzong in Tibet, alike show a remarke similarity in foraminiferal facies to that of the Khairabad Limestone. ditions must have been very equable over great distances to have produced s similarity; and its extent - over more than forty degrees of longitude indicates that segregation must be invoked, rather than distance, to acnt for the distinction of Indian Paleocene forms from European ones.

A noticeable feature of the Ranikot deposits in the Kohat-Potwar basin so in Waziristan to the west, and in Tibet to the east) is the abundance them of ostracods. Practically no work has hitherto been done on Indian ine fossil ostracods; but after identifying Bairdia subdeltoidea (Münster) the Upper Ranikot beds at Thal, I found so many ostracods of other types so appearing in washings of Ranikot clays from different parts of the Ko-Potwar basin that I sent a considerable collection of them, besides ostcods from later Eocene beds, to Miss M.H.Latham for description. She ed the presence of nine species altogether, all of which are present in Upper Ranikot but only two of which have yet been found in later Eocene osits. B.subdeltoidea is the commonest species at all levels; but the ndance of Cytherids - represented by seven species - in the Ranikot is y marked, and quite unlike anything seen in later Eocene beds of this ion.

It will perhaps help those who cannot identify foraminiferal ecies with confidence, to note that the presence of many ornamented ostrads in an Indian Eocene bed is an almost certain indication that that bed ould be referred to the Ranikot. It may relieve the monotony with which rtain geologists dismiss any Eocene formation they see as simply "nummutic"; a practice which a student of the Eocene, searching records for deiled observations to add to his own, finds somewhat exasperating. He es consider that some effort should have been made to identify the stage, en if it is too much to expect that the zone should be recognised. The ting of the presence of ornamented ostracods would also be of more practal use than the habit of certain Indian geologists, when they think that rtain calcareous rocks probably belong to the earlier Eocene, but shrink om referring them to a particular stage, of calling them "Hill limestones." at expression has no exact stratigraphic value, and merely (as I have incated elsewhere) simulates definition while defining nothing.

The Patala Shales.

The sea appears to have become shallower again after Khairabad Limestone nes. The latest Ranikot deposits are best seen to the east - e.g. on the lt and Kalachitta ranges. They have already been described on the former; d in the Nahrwali nullah section of the latter they consist of about 400 et of shales and sandstones, with some thin calcareous bands. On both nges their lower portions are highly fossiliferous, and their upper levels ss so.

It seems significant that the Patala Shales of the Salt Range are generly darker in colour and more carbonaceous than those of the Kalachitta nge. Ranikot coal beds are found in the western parts of the Salt Range n the borders of the Kohat district) and at Dandot further to the east. nikot coal beds are also found in Sind. It should be remembered, in this nnection, that the area between the Kohat-Potwar basin and the proto-Sarasti river (which I believe carried down the carbonaceous matter which formed e southern coal deposits) was an old land surface, and very different from e recently emerged lands to north and west. The carbonaceous deposits on e borders of the older land surface indicate that it supported considerly more vegetation than the newer lands on the opposite side of the Ranit estuary.

The Nammal Shales.

Just as the Patala Shales constitute the latest known Ranikot element, do the Nammal Shales constitute the earliest known Laki element, of the cene of north-west India. The unconformity (elsewhere much more marked) tween the Ranikot and the Laki, is there reduced to the smallest proporons yet found in the Indian Eocene. These two zones, taken together, bably represent the extent of the unconformity licated by the "Basal Laki Laterite" of Nuttall's Sind sequence; for the ls below that laterite are about equivalent in age to the late Khairabad nestone, while the Meting Limestone which succeeds the laterite corresds approximately with the Sakesar Limestone of the Salt Range.

The earlier portions of the Nammal Shales are generally unfossiliferous, the earliest fossiliferous zones contain in places an abnormally large nixture of Ranikot forms which do not survive to higher levels. The Laki

aracter of the deposits is, however, indicated by the appearance of such
pical European species as Assilina granulosa (well seen at Kalabagh, on
e borders of the Kohat district), Nummulites atacicus and N.irregularis.
is clearly indicates that the segregation of Indian waters had come to an
d; and the fact that local conditions suited the invading European species
indicated by the way in which they throve and supplanted many of the Ind-
n ones.

The fact that geographical changes also occurred nearer at hand is sug-
sted by an alteration in the nature of the sediments, the Nammal Shales
ng much lighter coloured than the Patala Shales. I suspect that this
s due to the advance of the Afghan coast nearer to India, at the commence-
t of Laki times, as already noted. The increased elevation of northern
hanistan, which produced that advance, would have tended to increase the
unt of drainage coming from the west, as well as bringing it nearer; and
t may account for the lighter colour and more barren nature of the depos-
. How reduced the extent of the Kohat-Potwar basin had temporarily be-
e to the west, seems indicated by the limitation westwards of visible
mal Shales, which have only hitherto been found in the Salt Range and Tar-
bi sections in the eastern parts of the Kohat district. It is possible
t these shales extend a little further to the west, but evidence of their
ng so has yet to be found. Owing to the approach of the Afghan coast in
liest Laki times, it is possible that the Patala Shales may have been de-
ited much further to the west than they are now found, and may have been
oved in early Laki times. We cannot therefore draw the same inference
m the eastward limitation of the Patala Shales as we can from that of the
mal Shales. The dark colour and regular sequence of the Patala Shales as
n on the Salt Range seem to me to guarantee that the Afghan coast remained
a distance throughout the period of their deposition. At the same time,
can infer that the Afghan coast moved eastwards at the commencement of the
mal Shales period both from the change in colour and the irregularity in
tents of the Nammal Shales themselves, as well as from their limitation
the west; for the subsequent deepening of the waters renders it less like-
that Nammal Shales were removed from the west.

The later levels of the Nammal Shales merge, on the Salt Range, with the
er levels of the succeeding more calcareous formation, and it is often
ficult to say whether to attribute certain beds to the one or the other.

The Sakesar Limestone.

This formation is only found, so far as the Kohat district is concerned,
the Salt Range along its south-eastern border. It indicates a local deep-
ng of the Laki sea, and the corresponding westward movement of its western
st. The fauna of the Sakesar Limestone differs little from that of the
mal Shales, except for the disappearance of some of the larger and probab-
more littoral forms like N.irregularis and Discocyclina ranikotensis, and
abundance of Alveolines, notably A.globosa which similarly abounds in the
l Laki limestones of Sind and Baluchistan (known respectively as the Met-
and Dunghan Limestones). Its general facies seems, in fact, to agree
ty well with that of those limestones as recorded by Nuttall; and I have
found that the late Ranikot species N.lahirii, which survives through
Nammal Shales and probably extends into the lowest parts of the Sakesar
stone, appears in collections from the base of the Meting Limestone of
. I therefore provisionally correlate the Sakesar Limestone with the

nghan and Meting Limestones, which are the lowest fossiliferous Laki rmations in the south.

I have not found any very definite representatives of the Sakesar Lime-one further west in the Kohat district. Perhaps the water was not deep ep enough there to form such a limestone at the time, or the influence of e proto-Kurram river may have interfered with its development (the bed of at river having probably moved eastwards with the relative rise of land the west). Some thin limestones, separated by shales, occur in the Pan-a-Tarkhobi area, between the local Nammal Shales and Shekhan Limestone, d these may represent the Sakesar Limestone; but it would be a very re-ced representation.

The fact, however, that a considerable limestone like the Sakesar form-ion succeeds the Nammal Shales on the Salt Range itself, shows that the evation of the Salt Range axis had not begun when it was deposited. It uld not have been until later Laki times that the Salt Range axis first gan to rise.

The Bhadrar Beds.

This is a shallow-water series, which has hitherto only been found on e Salt Range. It indicates a local shallowing of marine waters, and is e last marine formation found on that range. It seems for the most part be highly fossiliferous; but although its fauna distinctly approaches e Shekhan Limestone facies, it does not (as I showed in the Salt Range moir) include some of the latest Laki elements which abound in the latter, l so appears to be of rather older date.

Dr.A.G.Brighton, curator of the Sedgwick Museum at Cambridge, kindly it me cores of the borings from the Jhatla well, about 12 to 15 miles rth of the Salt Range, on which Dr.Nuttall reported some years ago. I und that the uppermost layers of these, which Nuttall thought might belong her to the Laki or the Khirthar, can best be correlated with the Shekhan estone. They are definitely pre-Khirthar, but uppermost Laki, containing admixture of Lockhartia tipperi (a Ranikot and Laki species, never yet nd in the Khirthar) and Dictyoconus-group forms which make their first earance in the Shekhan Limestone, and for which I looked in vain among t Range collections. I also found that Shekhan Limestones constitute the ermost Laki elements exposed in the Chor Galli section of the Khairimurat ge, about 20 miles south-west of Rawalpindi. Thus the Shekhan Limestone undoubtedly developed to the north of the Salt Range; so its absence from Salt Range itself must either be due to its never having been deposited that locality, or to its having been removed subsequent to deposition. ncline to the former opinion, because it is strange - if later beds had n deposited - that none should survive in any part of this extensive and en much faulted range. The Bhadrar beds themselves have obviously been jected to denudation; and if they had been succeeded by a limestone, one ld expect some fragments of the latter to survive as protecting caps to softer shales. It also appears that Gypsum and portions of Lower Chhar-beds locally overlap onto the Salt Range without any sign of the Shekhan estone appearing below them. This seems clearly to indicate a degree of rgence and denudation of the Salt Range in late Laki times.

It has been claimed that a considerable section of the Sakesar Limestone ses laterally into Gypsum, which is held to be a local facies of that

imestone. It seems incredible, however, that a local concentration suf-
icient to produce gypsum should have not only occurred but continued
iroughout Sakesar Limestone times, in the middle of an open sea which
bounded with life on either side. I can imagine no circumstances capable
f producing such a continuous as well as extraordinary local effect. It
eems easier to explain matters by local action after Sakesar Limestone
imes. Flood-streams might dissolve out [redacted] limestone, leaving hol-
ows in which the desiccating waters of subsequent marine invasions could
eposit less soluble gypsum; and contact gypsification of the adjoining
imestone might afterwards produce an appearance of lateral transition.
provisionally regard some such explanation as accounting for the phenomena
n question. In any case, the phenomena must be accounted for by something
ich happened within Eocene times, and before the later Khirthar; and the
planation here offered, which seems the most reasonable, postulates a
egree of emergence of the Salt Range axis after the deposition of the Bhad-
ar beds.

Since the Bhadrar beds succeed a formation approximately correlated with
e Meting and Dunghan Limestones of the south, and antedate a limestone ap-
roximately correlated with the "Laki" Limestone of Sind, I regard them as
ughly contemporary with the Meting Shales of Sind and the lowest parts of
e Ghazij Shales of Baluchistan (see correlations, Text-figure 6) although
eir connections cannot be continuously traced with either.

The Shekhan Limestone.

This limestone was first described in my paper on the geology of Kohat
.924) when dealing with the sequence exposed in the Shekhan nullah four
.les east of Kohat; and although I gave it no name at the time (referring
it as beds "9" and "10" which I correlated with Vredenburg's "Alveolina
mestone") it has since acquired the name "Shekhan Limestone" among geolo-
sts who have visited the section to which I drew attention. I do not
ow who first employed this term, which is nevertheless very suitable since
ere is probably no better exposure of the formation. It is certain that
e term "Alveolina Limestone" must go. As Nuttall has shown, Vredenburg
nfused two very distinct formations under that name; and it is [redacted] with
e later one - which Nuttall called the "Laki" Limestone - that the old
ds "9" and "10" can best be correlated.

The Shekhan Limestone (as it is now called) is from 100 to 120 feet
ick as regards its more calcareous portions, and sometimes up to 200 feet
ick if we include large shaley intercalations. Outcrops of it appear
ong most exposures of Laki beds in the vicinity of Kohat, and are easily
stinguished from Khirthar beds by their yellower colour, more nodular
ture, and distinctive fossils - in particular _Alveolina oblonga_ and the
rm which I called _Assilina_ cf. _pustulosa_ in my Salt Range paper but now
describe as _A. shekhanensis_ n.sp. Mollusca are fairly common, and often
tter developed than corresponding forms in the succeeding Kohat Shales.
hinoids are also common (a characteristic which this limestone shares
th the "Laki" Limestone of Sind) and are often of large size; _Conoclypeus_
lgrimi Davies (related to _C. stephaninii_ Dainelli, of Europe) appearing in
ny exposures. The general aspect of the fauna is rich. It seems to in-
cate that, although desiccation followed so soon afterwards, conditions
f existence were very favourable to littoral forms just before it began.

Exposures of the Shekhan Limestone to east of the Indus show it to be re massive there than to the west. As already noted, it has been traced far as the Khairimurat range in the east, and is present under later ertiary deposits a few miles north of the Salt Range. When discussing the rrelation of Pinfold's Chharat series (1926) I treated the limestone unrlying the same as equivalent to the Shekhan Limestone (which I was then lling the "Alveolina" Limestone). I still think this correlation correct; t the relatively unfossiliferous nature of the limestone at Chharat is not rmal for the Shekhan Limestone, and I suspect that the difference is due fluviatile influence along the northern shore of the Kohat-Potwar basin that time.

It is certain that the north-western portion of the Himalayan axis had then risen, and it had probably completed severing the connections of e Kohat-Potwar basin with Tibet. It would follow that the drainage of er a thousand miles of trans-Himalayan area, which had previously passed t to sea <u>via</u> the long estuary, would be trying to find its way round the ds of the newly-risen obstacle. The portions of the ponded waters which und their way round the northern end of the obstacle would probably deend, at first, in the form of a number of streams upon the northern shores the Kohat-Potwar basin (see Text-figure 4). That would presently tend make the waters adjoining that shore more brackish than the waters furer south and south-west, and may account for the relative absence of forinifera in the north-eastern aspect of this limestone. The early distribed nature of the descending streams might also account for no pronounced cal delta being found. Later on, however, after one of the streams had cceeded in deepening its bed more than the others, it might capture the hers - or at least secure the greater part of the discharge from the orinal source; - and having well established its course, it might subseently maintain the same by continued cutting down across the axis of the ill rising Himalayas. This is how I would account for the origin of the per Indus valley (compare Text-figures 4 and 5), which passes northwards om the Kohat-Potwar basin, and curves round in a broad arc across the Himayan axis to find, and subsequently adhere to, the latest course of the ans-Himalayan Eocene sea, cutting three enormous gorges through the Ladak nge in order to take that course. (I cannot attribute this phenomenon to mple head-erosion by a tributary of a late "Indobrahm" river, as suggested Pascoe, or of Pilgrim's still later "Siwalik" river. In my opinion, the per Indus established its course before, not after, the lower Indus. The per Indus was in existence long before the lower Indus ceased to be an tuary.)

Discussion of Himalayan developments and the origin of the upper Indus seem remote from the Kohat district; but I cannot dissociate these ngs. The Kohat district forms half of the Kohat-Potwar basin, the inter- geological history of which is intimately related to events at either l of the basin. It seems significant that Mr.E.R.Gee found a number of ll fishes in shales intercalated with gypsum, immediately above the Shen Limestone level, near Malgin ($33^{o}19\frac{1}{2}$:$71^{o}31\frac{1}{2}$') about 20 miles E.S.E. of at; and although these fishes were described as estuarine forms by Dr. der Lal Hora (1937), they are definitely regarded by Dr.E.I.White as ng all undoubtedly freshwater forms (Cyprinoids, etc.). ~~xx~~ Dr.White kindly let me see his (unpublished) description of these forms. If the per Indus and Jhelum rivers had, as I think, established themselves by n (see Text-figure 4), freshwater fishes might well have been carried by m into and across the basin where fluviatile and marine conditions were ll struggling for ascendancy. I cannot think that these fishes were ught by the proto-Kurram river, for they appear too far to the east. proto-Kurram river discharged its contents southwards, well to the west.

In any case, whatever the explanation may be, the north-eastern facies f the Shekhan Limestone seems to be less fossiliferous than its facies nywhere else; and its eastern facies in general is more massive than its acies round Kohat. As it is traced westwards from Kohat, this limestone ecomes progressively thinner and more shaley, and near the western borders f the Kohat district it appears only as a few calcareous and fossiliferous ayers capping a considerable thickness of unfossiliferous shales whose [redacted] base is not seen. What the age of these underlying hales may be it is difficult to say, owing to the recurrence of shales [redacted] c. of identical aspect throughout the Cretaceous and most of the Eocene north-west India. A few miles to the east of Thal, the last traces of hekhan Limestone fossils disappear; yet the shales seem to continue as efore - and to south of Thal they are capped by calcareous layers with nikot fossils. The phenomenon is disconcerting, but unmistakeable. It impossible, apart from the cappings of fossils of very different age, to stinguish between the underlying shales, which seem to be continuous gardless of cappings.

The reduction in thickness of the Shekhan Limestone to the west, and e absence of recognisable Lower Laki elements, indicates the shallowing the Laki basin. If denudation removed later Ranikot elements to the st, while similar shales were still laid down to the east, Laki fossils ght seem to succeed the same beds to the east as Ranikot fossils succeed the west.

These appearances originally deceived myself, for when describing the nikot beds at Thal (1927) I showed what I took to be "Meting Shales" arked "j - j" on Fig.8, opposite p.286) overlying the fossiliferous Ranit beds (marked "e - e"). They were exactly like Laki shales which I had en elsewhere, and I suspected nothing, being engaged on proving theRanit age of the underlying beds. At my last (1935-1936) visit, however, I und that some very thin calcareous layers immediately underlying bed - k" (which is really of Khirthar age, not Laki) were full of Ranikot ssils. In fact, there was no Laki there at all, the Khirthar overlapping rectly onto the Ranikot. And yet my continuous mapping had just proved at true Laki beds, of exactly similar aspect to these supposed "Meting ales", approached within a few miles of this very section.

It was after this that I pointed out (C.R.S.S.Soc.géol.Fr., 1938) in position to [redacted] Dr.A.M.Heron, that fossil evidence must be found fore Waziristan shales can be safely attributed to the Laki.

The Passage-Beds, Petroleum, Gypsum and Salt.

Mr.E.S.Pinfold and Sir E.Pascoe have dealt the most fully with the estion of the sources of oil in the Punjab, and seem to agree that the oductive horizon is at or near the level of the "passage-beds" at the base the Lower Chharat. Mr.Pinfold showed me the type section for these beds Chor Galli, on the Khairimurat range. The Upper Chharat is there missg; and Murree beds overlap onto rather over 200 feet of Lower Chharat ds, which conformably suddeed about 230 feet of "passage-beds", which in rn conformably follow the Shekhan Limestone.

About two-thirds of the passage-beds in this section consist of limenes, which vary from a few feet up to 30 or 40 feet in thickness, and alrnate with shales throughout the series. The lowest limestones are mass-ve, the intermediate ones flaggy and the upper ones marly. All these assage-bed limestones are of a very peculiar and characteristic type, being crowded with minute fissures at right angles to the bedding. These issures are filled with calcite and gypsum which, being less soluble than he matrix, stand out on weathering and give the rock a very stringy appearance. Pale yellow to grey colours characterise both the limestones and he shales of the series, yellow tints predominating in the upper beds and reys in the lower ones.

The only unconformity in the series appears at the base of the Murree eds, where derived fossils and rolled rock fragments form a "Fateh-Jang" one. The only gypsum in the section appears in the fissures of the passaged limestones, besides a few traces in the Lower Chharat shales.

Gypsum is, indeed, very little seen to the east of the Indus, if we exept the gypsum and salt of the Salt Range itself. I do not propose to disuss the Salt Range gypsum etc. here, because it is in a faulted and anomalus position, if it be of Tertiary age.

Gypsum and salt (apart from the Salt Range) are much better developed to est of the Indus, and may be said to appear over a belt which is about 20 iles broad at its western end (from a little south of Latambar to rather rth of Gurguri) and runs east-north-east from there to the Indus. Both .salt and gypsum are very variable in amount, but the larger quantities pear in the southern and south-western parts of the belt. Their distribuons are best seen on Wynne's map of the southern portion of the Kohat disict, for only some of the northern fringe of the belt enters the portion the district mapped by myself. Gypsum is much more commonly seen than lt (as Wynne's map shows); and this is what might be expected, owing to e much greater solubility of the salt. In all cases known to me, the salt derlies the gypsum; and I never saw the base of the salt, its contact with bjacent beds being always either hidden or faulted.

The base of the gypsum, however, where not connected with salt, was oftseen; and with singular consistency it appeared to be at or about the me horizon as the base of the passage-beds. Thus from Daud Khel village ear Shadi Khel) for about a mile to the west, there is a series of gypsum nticles, measuring from about 4 to nearly 100 feet in thickness, which metimes lie on small quantities of passage-bed limestones, and in other ses have thin seams of such limestones interstratified with them. In all ses, Shekhan Limestones and shales form the base of the series, and Lower harat beds succeed the gypsum. Similarly at Panoba, where the gypsum is om 80 to 150 feet thick, it is underlain by 25 feet of passage-beds, which erlie Shekhan Limestones; while above the Gypsum come 300 feet of Lower harat beds.

In these cases, as in others, the passage-beds are very reduced in quanty, and the gypsum either immediately succeeds them or is interstratified th them and survives them. That the gypsum continues into Lower Chharat nes, is occasionally seen by its interstratification with Lower Chharat ds. This is well evidenced at Tarkhobi, where the top of the Shekhan nestone seems to be marked by a 2-ft. _Ostrea_ band, succeeded by 25 to 30 t of green and yellow, sometimes sandy, shales and limestone bands, the per parts of which become gypsiferous, while some of the limestones are of ssage-bed type. After that come the following:

Gypsum	38 feet.
Red shales . .	70 " .
Gypsum	10 " .
Red shales . .	45 " .
Gypsum	2 " .
Red shales . .	30 " .
Gypsum	$\frac{1}{2}$ " .
Red shales . .	80 " .
	$275\frac{1}{2}$ " .

In every case that I saw during my last general survey, the large masses gypsum of the Kohat district lay at the same horizon, i.e. above the Sheɑn Limestone, and were either interstratified with or below the succeeding wer Chharat. Thus they were either in, or both in and slightly above, the sition occupied by the passage-beds. The most western gypsum lenticles at I found appeared in an outcrop a mile or so north and north-west of nda Anarchina village ($33^{\circ}22\frac{1}{2}':71^{\circ}1\frac{1}{2}'$); they were from 30 to 50 feet in ickness, and similarly lay between Shekhan Limestone beds and succeeding wer Chharat ones.

I have therefore abandoned my earlier opinion (1929) that the main riod of deposition of the salt and gypsum was between the Ranikot and the ki. I now believe that it was at the close of the Laki. It was not dis-iated from, but immediately preceded and led up to, the fluviatile Lower harat phase in the same area.

It seems to be worth noting that the passage-beds are best developed to east of the Indus, while the main gypsum deposits are to the west of at river. Gypsum deposits and passage-beds overlap to some extent the north-eastern parts of the Kohat district. It may be significant t, if we ignore the faulted and abnormal Salt Range area, the oil seep-s etc. shown on Sir E.Pascoe's map seem to be mainly distributed over the ion where the passage-beds appear; and certainly the main oil wells are the east of the Indus, where those beds are thickest. On the other hand, region where the gypsum and salt are best developed is the one where iodic marine incursions from the south would have brought fresh salt ers to be desiccated out; and the fact that the gypsum does not extend ther to the east may indicate that the influx of fresh waters (probably m the upper Indus and Jhelum rivers) prevented desiccation from becoming plete in the deeper eastern parts of the Kohat-Potwar basin of the time. any case, the passage-beds seem to represent the product of conditions t developed in the eastern parts of the Kohat-Potwar basin at that time; those conditions were apparently the most favourable for the production oil.

The Lower Chharat beds.

Although passage-beds exist in the Panoba-Tarkhobi exposure some 30 miles t of Kohat, and small quantities near Shadi Khel about 10 miles south of at, I saw none either round Kohat itself or in the Miranzai valley to the t. The northern parts of the Kohat district (except to the east) show traces either of passage-beds or of gypsum, the Lower Chharat beds of se parts immediately succeeding the Shekhan Limestone.

The upper levels of the Shekhan Limestone in these north-western parts the Kohat district assume a definitely shallow-water facies, calcareous dstones and grits appearing in them, often accompanied by an Ostrea-band.

the other hand, the succeeding Lower Chharat beds of these parts often ntain Laki foraminifera in their lowest levels; so the sequence appears be perfectly conformable.

It is interesting to note the changes in the character of the Lower harat beds. To east of the Indus - on the Khairimurat range and at harat itself - they are represented by variegated shales and limestones; e latter are sometimes crowded with <u>Planorbis</u>, while the former contain casional Chelonian plates and reptilian bones. In the southern and eastn parts of the Kohat district the Lower Chharat is [redacted] principally presented by dark red shales, with occasional pisolitic bands of the same lour. These red beds compose what Wynne called the "Red Clay Zone" in s descriptions of the southern parts of the Kohat district. They are distinguishable in colour etc. from some of the succeeding Murree beds of ch later age; and in one case at least Wynne mapped Murree beds as Eocene mistake. (This was on the extreme north of his map, longitude 71°11', out a mile south of "Wullai" village. I went over the actual spot, and und no Eocene outcrop.)

Near Kohat itself (also at Bahadur Khel, and in other south-western ctions) red sandstones make their appearance among the red shales. Rep-Lean bones occasionally appear, as to the east of the Indus. Further st, however, in the lower Miranzai valley and adjoining valleys immediate- south of it, dark brown to black grits begin to be seen at the base of e Lower Chharats, forming a well-marked horizon. These sandstone and grit ds increase in thickness and number to the west, and soon become interersed with thin conglomeratic layers. The conglomerates in turn become cker and more numerous, as traced to the west; and although they are at st black to rusty in colour, they afterwards (<u>i.e.</u> further to the west) sume a very characteristic yellowish-brown appearance, with highly calcars matrix, and usually emit a porcellaneous ring when struck with a ham-. They are quite unlike later Tertiary conglomerates of the same region, are easily distinguished from them even at a distance by reason of their uliar colour. Their contents are equally characteristic, consisting for most part of cherty white and pink pebbles - probably from the "Parh" e of Cretaceous beds to north-west and west; - but they also often contain estone pebbles of Cretaceous, Ranikot and Laki age. Round Hangu these bles are sometimes 8 or 9 inches in diameter; further west they are somees still bigger, although most of the pebbles are always much smaller.

Shales separating the conglomerates and sandstones still generally ren their red aspect, although the lower shales are often yellow in colour e the underlying Shekhan shales; but in spite of the progressive coarsen- of the formation to the west, its total thickness decreases. Round Ko- and to the east of Kohat (Panoba, etc.) the Lower Chharat is about 300 t thick (locally varying from 250 to 350 feet); near Hangu its thickness often only about 50 feet. After that it still decreases down to [redacted] ut a dozen feet or less, until near Sarozai the formation suddenly expands a great thickness of sandstones, conglomerates and shales. The conglomtes are of typical Lower Chharat type, and sections of the sandstones w Laki foraminifera and a proportion of wind-rounded sand grains. I could measure the formation, owing to the faulted and disturbed nature of the osures seen; but its thickness could hardly be less than 400 or 500 feet, might be much more. This thickness is local, however, extending only a few miles to the west (the whole visible outcrop covers about 12 are miles), after which the formation rapidly decreases again in size. is only 4 to 8 feet thick near Dallan, and finally disappears near Thal, ittle beyond the last apparent traces of the Shekhan Limestone.

This great local development of the Lower Chharat sandstones and con-
omerates near Sarozai suggests a river deposit - probably a delta - and
would identify that river with the proto-Kurram river whose Ranikot delta
pears at Thal. The displacement of the delta some 15 miles to the east
Lower Chharat times seems to be correlated with the emergence of northern
ghanistan at the close of the Ranikot, and the consequent eastward move-
nt of the Afghan shore-line. The raising of contours to the west would
nd to force the river to take a more eastern route; and in adopting that
ute, the river would wear through what were then the most recent rocks
ate Cretaceous and early Eocene) as its contents seem to indicate.

The Kohat Shales.

I called this formation the "Kohat Shales" (1924) after its development
und Kohat. It is really the lower member of Pinfold's Upper Chharat ser-
s, and represents the return to marine conditions after the Lower Chharat
uviatile interlude.

Although nearly the whole of the Lower Chharat formation near Kohat is
a dark red colour, its uppermost layers assume purple tints, concluding
th about 6 feet of mauve to indigo-coloured shales, which are succeeded
about 2 feet of light grey limestone full of Planorbis. After this come
or 3 feet of unfossiliferous shales and thin concretionary limestones,
llowed by another 2 or 3 feet of grey shales with thin limestones contain-
g foraminifera; after which comes a calcareous band packed with small oys-
rs and megalospheric Assilines (A.subpapillata). Thus the change from
uviatile to marine conditions is fairly abrupt; but there seems to be
ttle if any unconformity. Both the Planorbis band and the Ostrea band
e to be seen in most exposures round Kohat; but the junction of Lower and
per Chharat beds is also often marked by a prominent light-coloured band
hard cherty limestone, from 4 to 8 feet thick, which seems to take the
ace of the few feet of intervening shales and concretionary lime-
nes.

Following the Ostrea band comes a succession of light-coloured shales
llowish to east of the Indus, greenish-grey to west) alternating with a
ber of thin limestone bands. The limestones are thickest and most
wded about the middle of the sequence, where two or three bands from 4
6 feet thick usually appear close together, with many molluscan casts
quenting the thin shales between them. The uppermost levels of the Ko-
Shales afford the richest horizon for N.laevigatus and N.carteri, and
m to merge with perfect conformity into the succeeding Nummulite Shale.

The total thickness of the Kohat Shale is about 45 to 50 feet at most
the Chharat area. I examined the type section in the Bhagwan Kas nullah
detail, paying several visits to it, and found that Mr.Pinfold's estim-
of 100 to 200 feet for this formation there is far too great, the beds
ng much faulted and repeated. The thickness of the formation increases,
ever, as it is traced to the west, being about 80 feet at Panoba, in the
tern parts of the Kohat district, and 85 to 90 feet round Kohat itself.
then generally decreases in thickness to south-west and west; being about
feet at Bahadur Khel, 50 feet at Latambar, and 30 feet at Thal. As Mr.
fold remarked, the formation is not very fossiliferous near Chharat (al-
ugh the fossils that do appear are of the same types as elsewhere); its
tern outcrops are much more fossiliferous. This may be due to the more
ckish nature of conditions to the north-east, if the early upper Indus
Jhelum rivers were discharging there as I suspect (see Text-figure 5).

I originally (1924, 1926 etc.) regarded the Kohat Shale as a trans-
ional bed between the Laki and the Khirthar. That was because the Palae-
tologist at Calcutta, on whom I depended for foraminiferal identifications
fore I knew much about the subject myself, reported finding Assilina gran
osa, N.atacicus and Alv.oblonga in my collections from near the base of
e Kohat Shale, and N.laevigatus and N.perforatus from near its summit.
own work on these forms has since shown that the supposed A.granulosa is
lly A.subpapillata, and the supposed Alv.oblonga are young Alv.javana.
ttall has also shown that N.atacicus survives far into the
rthar instead of being confined to the Laki as thought by Vredenburg.
e N.perforatus I would now prefer to call N.uroniensis. I therefore now
er the whole of the Kohat Shale not only to the Khirthar but to the low-
portions of the Middle Khirthar, and regard the Lower Chharat beds as
relating not with the Ghazij Shales as I formerly supposed (1924) but
h the Lower Khirthar.

Conspicous among the Kohat Shale forms are Dictyoconoides kohaticus,
eolina javana, Alv.violae and a Nummulite allied to N.beaumonti but
ller, and with rather excavated pustules at the poles. This was called
amondi in my early papers, and has been referred to N.beaumonti by other
logists; but it certainly is not N.beaumonti s.str., and I now regard it
a new species and redescribe it as N.pinfoldi. It may be a premutation
the true N.beaumonti, which appears at a higher level both in India and
Europe. N.pinfoldi is one of the commonest and most constant species
nd in the Kohat Shale, but I have never yet seen it at any other level.
e the true D.kohaticus it is, locally at least, a zone fossil for the
at Shale.

The Nummulite Shale.

This is the upper element of Pinfold's Upper Chharat series, and was so
ed by Pinfold because of its aspect in the type area (Bhagwan Kas nullah,
r Chharat) where it is composed of masses of loosely compacted foramini-
a. Assilines are very common in it, being chiefly represented by A.pap-
ata and A.exponens with their megalospheric companions. N.atacicus and
roniensis are also common; and towards the top - which becomes very ar-
laceous and in places almost a pure clay - many Discocyclina dispansa
ear. Faulting and duplication greatly increase the apparent thickness
this foramation which, so far as I could judge, is only about 100 feet
ck in the Bhagwan Kas nullah. Pinfold, who stated that it varies from
to 200 feet in thickness, figured it as measuring about 200 feet in that
tion. I therefore - judging from that section - doubt if it ever meas-
s much more than 100 feet to east of the Indus. I never, myself, saw it
ain much greater thickness anywhere.

In the Panoba section, a little west of the Indus, I found the Nummulite
e to be about 60 feet thick. Alv.violae appear in it there, as also in
underlying Kohat Shale of that section.

In the Shekhan nullah near Kohat this formation, although much more com-
ted than to the east of the Indus, is still quite distinct from the mass-
limestones which succeed it, and is 120 feet thick. Nummulites there
ominate over Assilines, although the species themselves remain much the
e as to the east. Alv.violae also appears, though less commonly than in
er parts of the Kohat district. I saw no Discocyclina dispansa in the
t district. Its abundance in the highest and most argillaceous portion

the Nummulite Shale at Chharat may either indicate a preference for
allow-water conditions, or tend to correlate that portion of the eastern
mmulite Shale with a later horizon to the west. (In any case it seems
gnificant, with reference to the shape of the Kohat-Potwar basin at that
me, that the Nummulite Shale to the east is capped by clays, while to the
st it is succeeded by massive limestones.)

In the western parts of the Kohat district the Nummulite Shale becomes
ill more calcareous. It is sometimes indistinguishable from the succeed-
g limestones, except for the greater abundance and crowding of its fossil
ntents; at other times it is flaggy or nodular, and interspersed with
ales or clays. Round Thal it is very variable; but I could still rather
ubtfully recognise it as consisting of about 40 to 45 feet of rather
aley to flaggy grey limestones, with Alv.violae and abundant Dictyoconus-
oup forms. Its fauna there is mainly distinguished from that of the
derlying Kohat Shales by the absence of Dictyoconoides kohaticus and
pinfoldi, both of which abound below it.

One of the main differences between the Nummulite Shale and Kohat Shale
most exposures of Upper Chharat beds, is found in the relative abundance
molluscan casts in the Kohat Shale, and the absence of all molluscan re-
ns in the Nummulite Shale except for a large Pycnodont and a small Pec-
n. I have never seen this Pycnodont (which is very like Ostrea vesicular-
at any other level in the Kohat Eocene; but it appears in Nummulite
ale outcrops all over the Kohat-Potwar basin, and at the corresponding
rizon in Baluchistan etc. far to the south.

The Kohat Limestones.

Succeeding the Nummulite Shale in the Kohat district comes a consider-
e thickness of limestones, roughly divisible into two portions which I
pose to call, respectively, the Lower and Upper Kohat Limestones.

These beds have not previously been given separate treatment by any
ter. They, together with the underlying Nummulite Shale, were described
"Nummulitic" and "Alveolina" limestones by Wynne (1875, etc.) when deal-
with what he called the "Nummulitic series" (which included the Kohat
les) of the southern parts of the Kohat district. Pinfold's subsequent
aration of the lower elements (Nummulite and Kohat Shales) of that ser-
, as seen to the east of the Indus, under the designation of "Upper
arat" beds, necessitates the separate treatment of those later elements
Wynne's "Nummulitic series" which are seen to the west of the Indus.
ce the name "Kohat Limestones" which I propose to attach to them, as
icating both their more calcareous nature and their especially fine de-
opment in the Kohat district.

The Lower Kohat Limestone is a massive fine-grained one, light to dark
y in colour. It is particularly well seen in the Shekhan nullah, where
is about 120 feet thick, and divisible into three parts. Its lowest 10
t are transitional from the Nummulite Shale, slightly shaley to flaggy in
e, and crowded with foraminifera; the next 55 feet are of grey colour and
sive in type, with fossils less crowded and weathering out only in ~~places~~
es; the uppermost 55 feet are of lighter grey colour, still massive in
e, and with still fewer fossils showing.

The Upper Kohat Limestone is only about 50 feet in thickness, but is
rly distinct, being a hard yellowish limestone which, although not very

dular in the Shekhan section, is often distinctly nodular elsewhere. In st cases it is full of globular Alveolines and contains many Orbitolites mplanatus.

Thus the total thickness of the Kohat Limestones is about 150 feet near hat. If the 120 feet of Nummulite Shale be added to this, it makes a to- l of nearly 300 feet of Khirthar limestones. Adding the 85 feet of Kohat ale makes a total of over 375 feet of marine Khirthar beds, excluding the rki Shales which would bring the total up to a little more than 400 feet. we add the 200 to 300 feet of Lower Chharat beds, it makes a grand total between 600 and 700 feet of Khirthar rocks, of which about the lower two fths are fluviatile.

Near Thal, the lower grey limestone is about 15 to 20 feet thick, while e upper yellow limestone - which probably indicates shallower water - ries from 30 to 50 feet in thickness.

The lower and grey-coloured section of the Kohat Limestones is, on the ole, less fossiliferous than either the Nummulite Shale below it or the llowish and nodular (yet very hard) limestone which succeeds it. This st, and uppermost, section of the Kohat Limestones usually offers a very stinctive appearance in the field; its rather livid yellowish appearance king it recognisable from great distances, as it caps successive anti- ines from which the later but softer Tertiary sandstones and shales have en removed. It thus often indicates the outcropping of Eocene beds long fore they are reached.

Not knowing the details of the local succession, which are best devel- in the northern parts of the Kohat district, Wynne greatly overestimated e total thickness of the Eocene beds which he saw in the Miranzai valley, nce he failed to recognise the fact when the same sequence repeated or versed itself in faulted or successive anticlinal and synclinal sections, d so added the whole together. I have prepared two sections, correspond- g to the two shown by Wynne in his short paper describing this area, in der to indicate the true nature of the sequence which he largely misin- rpreted. (I wish to emphasise again, however, that I have the greatest miration for the consistency and thoroughness of Wynne's work whenever had the chance of being thorough, as when dealing with the southern rts of the Kohat district. Considering the handicaps under which he boured, and the very short duration of his visit to the northern parts the Kohat district in which I myself lived for years, it is not surpris- g that I cannot always agree with what was really his record of first pressions.)

The Sirki Shales.

As already stated, I found these shales capping the Upper Kohat Lime- one in a number of synclinal valleys to east, south and south-west of ngu; the village of Sirki Pela (33°27':71°4') occupying a fairly central sition as regards the exposures. I therefore propose to call these the rki Shales. None of the exposures show a great thickness of beds; the ual amount being from 2 to 6 feet, and the largest one that I saw from to 30 feet in thickness. These beds should not be confused with the ateh Jang" zone, consisting of pebbles and fossils derived from older cene levels, which often appears at what seems to be the same horizon, r they are not incorporated with, but distinct from, the succeeding much ter Tertiary beds, and consist of regularly stratified yellowish shales th intercalated thin limestone bands, and contain a distinctive fauna of eir own, which indicates a slightly later Eocene date than that of the lerlying beds.

Some exposures of the Sirki Shales are closely packed with Assilines, l might be styled an Assiline shale. These Assilines are distinguishable m those of lower beds, being a well marked variant of A.papillata. I am scribing it as A.rota. I first saw this form in the upper[redacted] levels of Khirthar limestones at Spin Tangi in Baluchistan (the type area for the er Khirthar), where it is similarly abundant and accompanied by a variant Dictyoconoides kohaticus which I described (1926) as var.spintangiensis. ohaticus has not been found by me above the level of the Kohat Shales where in the Kohat-Potwar basin; it seems to be absent both from the Num- ite Shale and from the Kohat Limestones; but I did find D.kohaticus var. ntangiensis in considerable numbers in some exposures of the Sirki Shales re it accompanies A.rota just as it does at Spin Tangi. This again indi- es that the fauna of the Sirki Shales is not derived from lower levels is best correlated with the Upper Khirthar of Baluchistan. Another form ch is very common in the Sirki Shales, but found at no lower level (so as I saw) in the Kohat district, is Alveolina elliptica. Nearly all the eolines that I found in those shales seemed to be of that species, which in indicates that the fauna is not derived from lower levels. The near- species to A.elliptica is A.javana, which is very common in the Kohat les; but I never saw A.elliptica in the Kohat Shales.

Thus the Sirki Shales are characterised by at least three well-marked ms (belonging to three different genera) which are at least varietally tinct from, and yet related to, species found in the underlying Middle rthar beds; and the identity of two of these forms with ones peculiar far as I have seen) to the Upper Khirthar beds of Baluchistan justifies rovisional attribution of the Sirki Shales to the Upper Khirthar.

Other forms in the Sirki Shales are Orbitolites complanatus, a small ten very similar to the one seen in the Nummulite Shale below, a number small regular echinoids, and Cythereis bowerbanki - an ostracod which is sing from the immediately preceding limestones, and no doubt indicates a urn of estuarine conditions to this area just before the sea finally ired from it.

6. Post-Eocene deformation of Eocene beds.

This concludes the list of Eocene beds of the Kohat district. Later ene beds than Khirthar have not been found in this region. Indeed there a stratigraphic gap (so far as fossils are concerned) from the Upper rthar to the Lower Murree (i.e., from late Lutetian or Auversian to early digalian). This gap is, to my mind, the most puzzling feature about the ogy of north-west India. Conditions during the interval are not easy visualise. I can only suppose that the Kohat-Potwar basin became a lake, which the early upper Kurram, upper Indus and upper Jhelum rivers en- ed, while the overflow passed down the old channel connecting that basin the sea to the south. If rainfall was scanty, and the northern areas ren and not very elevated, sediments in the basin might only have accum- ted slowly; such organic remains as there were being destroyed before could be buried, and oxidation being carried to considerable lengths

; indicated by the strong red to purple colous of the sandstones and
ales.

There seems, however, to have been little deformation of the Kohat-Pot-
r basin itself until long after the Eocene. The succeeding deposits,
om Murree to Nagri times inclusive, appear to conform as regards strati-
cation very fairly well with the underlying Eocene; such differences of
p etc. as I saw indicating no great degree of distortion of the older
ds. There is, however, a progressive overlap by later post-Eocene beds
the west, Kamlials (Helvetian), Chinjis (Tortonian) and Nagris (late
ocene or Pliocene) successively overstepping onto the Eocene to the west
Hangu. The Chinjis, which appear as the lowest post-Khirthar formation
ar Thal, there contain numerous pebbles, which I did not notice in beds
the same formation further to the east, and may indicate the influence
the early Kurram river.

Although, however, the approximate conformity in dip between Eocene
ds and later ones seem to indicate that no great deformation of the Kohat-
twar basin took place until the Pliocene, much deformation must then have
curred - indeed, the main present orogeny of the Kohat district must have
en acquired - for Pleistocene terraces in the Miranzai valley and in val-
ys to east and west of the Miranzai still retain their approximate hori-
ntality, and are inclined at much the same angles as recent deposits are
the outcrops of older beds forming the present orogenic features of the
strict. On one of these terraces, about 50 feet above the present level
the Kurram river in northern Waziristan, I found an early palaeolithic
plement similar to ones recently discovered in the Soan [redacted] syncline. In
lower Miranzai valley, thick Pleistocene conglomerates cap isolated
ls in the middle of the valley, and overlie the upturned edges of almost
tical Murree beds.

It is now well known that great changes have taken place to east and
th at the close of Pleistocene times; but although it is fairly common
find isolated masses of Pleistocene beds faulted into abnormal positions
the northern parts of the Kohat district, the general evidence there in-
ates that Pleistocene beds have not been much disturbed as a whole. In
south-eastern parts of the Kohat district, however, there probably was
siderable disturbance in sub-recent times. Pleistocene conglomerates
parts of the Salt Range near Kalabagh. The very survival up to the
sent of large exposures of such a soluble mineral as salt, itself indic-
s that the same cannot have been exposed for any great geological [redacted]
erval. This also applies, of course, to the Salt deposits at Bahadur
l etc.; and it is noticeable that the Kamlial and Chinji beds near Baha-
Khel are tilted at extreme angles, and covered by recent deposits only,
n in the valleys. I therefore suspect that although the main orogeny of
Kohat district was acquired in the Pliocene - perhaps the early Pliocene
there was an increase of the thrusting from north and west respectively
east and south of Thal, at the end of the Pleistocene or early in recent
es. This may not have caused much distortion (though it probably in-
ased the overthrusting) on the northern and western borders of the Kohat
trict; but I believe that the convergence of effects, through the Kohat
trict, on the south-eastern portion of the district, increased the dis-
tion and faulting in that region, with the consequent exposing of fresh
ses of salt which are still to be seen in large quantities between Baha-
Khel and the western Salt Range.

Another effect of this subrecent disturbance (which probably coincided

:h the elevation of the Pir Panjal range and the origin of the Sutlej rer) was probably the formation of the slight watershed which now divides Kohat district and prevents any considerable river passing through it; the quantities of Pleistocene conglomerates in the Miranzai valley seem indicate that a much larger river traversed it in early Quaternary times n any found in it now. It would be natural, as the post-Eocene lake ch occupied the Kohat-Potwar basin filled up with sediments, for the er Indus and upper Jhelum rivers to pass down that basin from east to t, join the upper Kurram river near Thal, and thence flow southwards as ombined stream along the course of the old lower estuary connecting the in with the open sea. I suspect that when the late Pleistocene disturbe took place, the [illegible] further thrusting from north and t not only "buckled" (so to speak) the Kohat district to some extent, ing a watershed traverse it from the Salt Range to the Samana, but also reased the relief and foldings of the western parts of the Salt Range elf and so blocked the course of the combined river south of Thal. The ult of that would be to turn the Kohat-Potwar region again into a lake, il overflows at various points on the crest of the Salt Range cut their nnels back through that range, draining the lake and establishing new rses for the respective lower waters of the three main upper rivers. Indus found its new channel across the Salt Range at Kalabagh, and was ned lower down by the Kurram river after the latter had cut through the t Range opposite Mianwali.

7. Palaeontology.

Descriptions of a condiderable number of Eocene foraminifera, and of a Eocene echinoids, of the Kohat district are to be found in my published ers. Descriptions of Eocene molluscs, corals, ostracods etc. which I lected in the Kohat district, have been given by Prof.J.W.Gregory, Mr. .Cox and Miss M.H.Latham. My work in connection with the present thesis the results of which work I hope also to publish in due course - has n divided between (a) mapping the geologically unsurveyed parts of the at district (comprising nearly a thousand square miles of hill country) attempting to reconstruct the Eocene history of the region (which has er before been attempted, since nobody has ever before zoned out the ian Eocene in a manner to allow of such a reconstruction), and (b) worksystematically through the fossil collections made during my last Indian it, in order to confirm or correct previously published descriptions, and deal with any new forms appearing in the collections.

To describe, here, all the species on which I have recently worked, ld make this paper very unwieldy to little purpose. In most cases, I ld only confirm former descriptions, or amend them in minor respects. I propose only to deal with the more important new species, and those species which either require to be re-examined for comparative purposes, need re-description because their significance demands fuller treatment n they have hitherto received.

The principal species in the latter class is N.beaumonti, D'Archiac and me, although it is a form which I have not yet found in the Kohat disct. It is nevertheless important for two reasons: (1) It is common in uppermost levels of the Spin Tangi section of the "Spintangi" beds of uchistan, and so helps to correlate those beds and their other contents h the Upper Eocene beds of Europe - a correlation which has never before

een established in regard to any Indian Eocene beds; - and (2) N.beaumonti
as never before been adequately fixed, by reference to the original mater-
l, with the result that Middle Eocene forms of India have been repeatedly
sidentified with it, while true representatives of the species - both on
e Indian continent and further east - have either been only doubtfully
entified with it or (more commonly) referred to other species.

Several of the forms accompanying N.beaumonti in the type section at
in Tangi also appear in the latest beds (the Sirki Shales) only, of the
hat district; and one of these forms is an Assiline (A.rota) which
s not hitherto been described. So I describe it, as well as re-describ-
g an earler form (A.papillata Nuttall) of which it may represent a muta-
on.

I also describe a new species of Nummulite (N.pinfoldi) which, in spite
s distinctive external appearance, may be a premutation of N.beaumonti.
is valuable as a zone fossil for the Kohat Shale. Whether or not it
isted before and/or after Kohat Shale times, I cannot say. It probably
d. But the conditions of Kohat Shale times seem to have suited it so
ll, as compared with the conditions of other times, that its appearance
any outcrop in N.W. India is good evidence that that outcrop should be
ferred to the Kohat Shale.

Another new species, Assilina shekhanensis, and its companion A.subshe-
anensis, are important as characterising Upper Laki beds.

Assilina tattaensis (d'Arch.& Haime) is redescribed, owing to
e imperfection of its original treatment, its subsequent neglect and mis-
entification with A.granulosa, and my recent discovery of its existence
the Kohat district.

Two distinctive Ranikot Alveolines are dealt with, also a new Ranikot
scocycline and its megalospheric companion.

The appearance of Alv.violae Checchia-Rispoli is recorded for the first
ne in India, and its representatives described as they appear in the Up-
r Chharat (Middle Khirthar) formation of the Kohat district, which corre-
onds with the horizon at which the species appears in Europe.

It may be interesting to note, with reference to the new horizon (the
rki Shales) found in the Kohat district, that the fauna of the Spintangi
ds (Vredenburg's "Upper Khirthar") with which Nuttall did not deal, and in
ich Vredenburg (1906, etc.) only quoted N.complanatus as a distinctive
ecies (the others cited by him being either doubtfully identified or also
und at lower levels), was found by me to include
e following more important forms:

Nummulites complanatus Lamarck. At the very top of the Spin Tangi (= "White Gorge" or "White Pass") section. The specimens found by me are poorly preserved, but seem to agree closely as to size, number of whorls, numbers and shape of chambers etc., with Fig.2, Plate I, of d'Archiac and Haime's monograph.

N.beaumonti d'Arch.& Haime. In the uppermost layers only, of the Spin Tangi section.

Assilina rota n.sp. In the upper layers of the Spin Tangi section.

It first appears below the level of N.beaumonti.

Dictyoconoides kohaticus(Davies), var.spintangiensis Davies. This accompanies A.rota at Spin Tangi. Upper levels of the section.

Alveolina elliptica (Sowerby). Upper layers of the Spin Tangi section. According to Nuttall (1926) Alv.elliptica characterises the Middle Khirthar. I suspect that the exposures in which he found it really belong to a later horizon. I never found it myself in true Middle Khirthar beds anywhere in the N.W.frontier of India, from Baluchistan to the Kohat-Potwar basin. On the other hand it is a constant companion, from Baluchistan to Kohat, of N.beaumonti and/or Ass.rota and D.kohaticus var.spintangiensis; and it similarly accompanies N.beaumonti both in Assam and in the Dutch East Indies (e.g. Soemba).

To the best of my belief, on the evidence as it stands at present, the ove-quoted five forms all characterise the late Khirthar deposits of Ina, which are probably equivalent to the Auversian of Europe and may posbly extend into the Bartonian.

This serves to fill the gap at present existing between the Middle irthar (definitely Lutetian) beds of India, whose fauna was most fully scribed by Nuttall, and the Oligocene beds of Baluchistan etc., with N. termedius d'Archiac and N.clipeus Nuttall, which were noted by both edenburg and Nuttall.

Nummulites beaumonti d'Archiac & Haime.

(Figures 1 to 8)

1853. Nummulites Beaumonti n.sp.; d'Arch. & Haime, "Descr.An.foss.Gr. numm. Inde", pp.133-134, 181; Pl.VIII, figs.1-3.

1855. Nummulites Beaumonti d'Arch.& Haime; Bellard, "Catalogo ragioneto dei Fossili nummulitici d'Egitto", Mem.Acad.real di Torino, (2), XV, p.201.

1877. Nummulites Beaumonti d'Arch.& Haime; Lartet, "Explor.géol.de la Mer Morte", p.161.

1883. Nummulites Beaumonti d'Arch.& Haime; De la Harpe, "Monographie der in Aegypten und der libyschen Wüste verkommenden Nummuliten", Palaeontographica, XXX, pp.180-182; Pl.XXXI, figs.37-47.

1902. Hantkenia beaumonti (d'Arch.& Haime); Prever, "Le Nummuliti della Forca di Presta, nell' Appenino Centrale e dei dintorini di Potenza nell' Appenino meridionale", Mem.Soc.Pal.Suisse, XXIX, p.95; Pl.IV, fig.40.

1908. Nummulites cf. Beaumonti d'Arch.& Haime; Dalton, "Notes on the Geology of Burma", Quart.Journ.Geol.Soc.Lond., LXIV, p.612.

1902. Nummulites Beaumonti d'Arch.& Haime; Martelli, "I fossili dei terreni eocenici di Spalato in Dalmazia", Palaeontographica Italica, VIII, pp.46,50,59; Pl.VI, fig.7.

1912. Nummulites beaumonti d'Arch.& Haime; Cotter, "The Pegu-Eocene succession near Ngape", Rec.Geol.Surv.Ind., XLI, pp.226, 234,236.

1912. Nummulites kelatensis Carter; Douvillé, "Les foraminifères de l'Ile de Nias", Samml.des Geol.Reichsmuseums in Leiden, (i), VIII, p.262.

1929. Nummulites beaumonti d'Arch.& Haime; Llueca [redacted], "Los Numulitidos de España", pp.146-147; Text-fig.29.

1929. Nummulites Beaumonti d'Arch.& Haime; Rozlozsnik, "Studien uber Nummulinen", Geol.Hungarica, (geologica), fasc.2, pp.118-123.

1929. Nummulites Kelatensis Carter; Van der Vlerk, "Groote foraminiferen van N.O. Borneo", Wetensch.Meded.v.d.Dienst v.d.Mijnbouw, No.9, p.19, fig.10,32a-b.

1930. Nummulites atacicus Leymerie var.Beaumonti d'Arch.& Haime; Cuvillier, "Révision du Nummulitique égyptien", Mém.Institut d'Egypte, XVI, pp.139,276; Pl.XV,figs.3-5; Pl.XVI,fig.16.

1932. Camerina densa n.sp.; Doornink, "Tertiary Nummulitidae from Java," Verh.Geol.Mijnb.Genootschap v.Ned.en Kol, (geol.), IX, p.295; Pl.XIII, figs.1-5.

1934. Camerina cf.kelatensis (Carter); Caudri, "Tertiary Deposits of Soemba", pp.53-56; Pl.I, figs.4-5,10.

1937. Nummulites Beaumonti d'Arch.& Haime; Doncieux, "Contrib.à l'Étude géologique de la Côte Libano-Syrienne: Les Foraminifères éocènes de la Syrie septentrionale", p.211; Pl.XII,figs.1-2.

1938. Nummulites Beaumonti d'Arch.& Haime; Flandrin, "Contribution à l'Étude paléontologique du Nummulitique algérien", Matériaux pour la Carte géologique de l'Algérie, (1), Paléontologie, No.8, pp.58-59; Pl.IV, figs.24-26.

In the uppermost levels of the Khirthar limestones at Spin Tangi
°55':68°8'), in the type area for the Upper Khirthar, and accompanied by
omplanatus which Vredenburg treated as only appearing in the Upper Khir-
r, I found many lenticular Nummulites which seem to be identifiable with
rchiac and Haime's species N.beaumonti. The original types of that spe-
s are said to have come from Mount Carmel (32°45':35°2') and Egypt in the
t, and from the Simla Hill States ("Subathoo", 30°58':77°2') and eastern
gal ("Cherra Poonji", 25°15':91°47'; and near "Silhet", 24°53':91°56') in
a.

The original Indian types of this species are now lost; but 9 specimens
Egypt still remain in d'Archiac and Haime's collections in the Muséum
onal d'Histoire Naturelle in Paris, to which I was kindly given access

Professor C.Arambourg and Dr.J.Cottreau. I was able to identify, among
ese 9 specimens, the originals of d'Archiac and Haime's figures 1, 2 and
n their Plate VIII. I was allowed to photograph the original of figure
which is also shown as Fig.1 of this paper), and I have the approval of
f.Arambourg and Dr.Cottreau to cite it as the lectotype of the species.

The 9 original specimens vary from $5\frac{3}{4}$ by $2\frac{1}{2}$ mm. to $10\frac{1}{4}$ by 3 mm. in
e, the average dimensions being 8 by $3\frac{1}{4}$ mm. The lectotype measures 9 by
mm., and the stoutest form is the original of figure 3 which measures
by $4\frac{1}{4}$ mm. A form of average diameter (8 mm.) has 12 to 13 whorls. The
mbers are about $1\frac{1}{4}$ to $1\frac{1}{2}$ times as high as long. There are about 54
mbers in the 10th whorl. Chamber partitions are almost straight, in-
ned at about 10° to the radius at bottom, and only slightly recurved at
. There are 3 whorls in the outer half of a radius measuring $2\frac{1}{2}$ mm.
as allowed to prepare a meridian section of one of the less well pre-
ved specimens, and this elicited the fact that the species possesses
ied polar pustules, which extend between 0.8 and 0.9 mm. from the centre
ng the axis on either side. A remarkable feature, which becomes visible
the photograph of the lectotype is examined under a lens, is the presence
transverse trabecules on the filaments.

The Spin Tangi forms agree fairly well with this. They vary from $5\frac{1}{4}$ by
mm. to 10 by $4\frac{1}{2}$ mm. in size, the average dimensions of a large number
ng $7\frac{1}{2}$ by $3\frac{1}{4}$ mm. The ratio of thickness to diameter seems constant at
ut 1:2.3 for all sizes, although individual variations range from 1:2.0
n to nearly 1:3.0. The spire is very regular, chambers and whorls in-
asing slowly and evenly in size. Specimens of average diameter ($7\frac{1}{2}$ mm.)
e 12 or 13 whorls, with about 60 chambers in the last one. There are 3
rls in the outer half of a radius measuring $2\frac{1}{2}$ mm. The marginal cord is
n, not exceeding one-sixth of the height of the subjacent chambers. (This
be thinner than in d'Archiac and Haime's types, in which the cord ap-
red to equal about a quarter of the height of the subjacent chambers.)
chambers are about twice as high as long in the inner whorls, but their
ght hardly exceeds their length in the outer whorls. Chamber partitions
almost straight, nearly vertical at bottom, and only slightly recurved
top. The test is smoothly lenticular, with septal filaments almost
aight at the periphery but curved round at the poles. Meridian sections
w very characteristic buried polar pustules, which extend about half way
m the centre to the surface, and are more or less abruptly succeeded by
ttered polar pillars which themselves fade out before reaching the sur-
e. Transverse trabecules are sometimes seen, but are rudimentary.

Distribution. I have only hitherto found this species in the uppermost
Spin Tangi beds of Baluchistan, and in collections from
ene beds near Siju (25°22':90°47') in eastern Bengal, not far from Cher-
unji where some of d'Archiac and Haime's original Indian types of N.beau-
ti were collected. Both Dalton and Cotter thought they found N.beaumonti
the uppermost Eocene beds near Kyet-u-bok (19°59':94°40') in Burma, and
is probably to this species that they refer. The species certainly ap-
rs beyond Burma to the south-east, for it has been figured and described
.kelatensis etc. by Dutch palaeontologists
have found it in the Eocene beds of the Dutch East Indies. The buried
ar pustules of the Dutch E.I. form are well seen in a meridian section
wn by Dr.C.M.B.Caudri, who is one of the few palaeontologists who realise
importance of systematically showing meridian sections as well as equat-
al ones in dealing with Nummulitidae. Doornink, who thought it a new

ecies, also shows the buried polar pustules (Pl.VIII, fig.3), and notes
e presence of transverse trabecules on the filaments. The degree of de-
.opment of these trabecules seems to vary a good deal.

In the opposite direction, the species seems to extend as far as the
stern Mediterranean, for it appears, though rarely, in Algeria. M.Flan-
n, who does not figure the meridian section, tells me that his Algerian
rms have buried polar pustules, and agree with my descriptions of the
lian type.

Llueca

As to the vertical distribution, [redacted] states that the species ap-
ars in the Auversian, Bartonian and Ludian; Doncieux states that the
yptian and Syrian N.beaumonti appear in the Upper Lutetian and Bartonian;
andrin says that the Algerian specimens appear in the Auversian. It is
ear, therefore, that the species is an Upper Eocene one. Its appearance
the top of the Spin Tangi section would indicate that the "Spintangi"
pper Khirthar) beds of N.W. India are either late Lutetian or post-Lute-
an in date, and may be provisionally referred to the Auversian.

Associates. The associates of N.beaumonti at Spin Tangi are Assilina rota n.sp. (described below), Dictyoconoides kohaticus var.
ntangiensis, Alveolina elliptica, Nummulites cf.complanatus, and some
ier forms which I have not yet worked out.

Illustrations.

Fig.1. N.beaumonti. LECTOTYPE. Original of d'Archiac and Haime's Plate VIII, fig.1. From Egypt; exact locality and horizon unknown. External view, magnified 4 times.

Fig.2. N.beaumonti. Specimen from uppermost levels of Khirthar limestones at Spin Tangi. External view, magnified 4 times.

Figs.3 & 4. As fig.2, but different specimens.

Fig.5. As fig.2, but lateral section, showing grouping of buried polar pustule and pillars near centre of test. Magnified 8 times.

Fig.6. As fig.2, but equatorial section. Magnified 8 times.

Fig.7. As fig.2, but meridian section, showing buried polar pustules. Magnified 8 times.

Fig.8. N.beaumonti. Specimen from Upper Siju, Garo Hills, Assam. Meridian section, for comparison with fig.7. Magnified 8 times.

Nummulites pinfoldi n.sp.

(Figures 9 to 14)

1924. Nummulites cf.ramondi Defrance; Davies, "Geology of Kohat", Journ.Proc.Asiat.Soc.Bengal, (N.S.), XX, pp.211,216,218-9.

1926. Nummulites ramondi Defrance; Davies, "Correlation of Pinfold's Chharat Series", Trans.Min.Geol.Inst.Ind., XX, pp.199,205.

1929. Nummulites cf.ramondi Defrance; Davies, "Age and Origin of Gypsum of Kohat", Trans.Min.Geol.Inst.Ind., XXIV, p.208.

liated form:

1926. Nummulites beaumonti d'Arch.& Haime; Nuttall, "Zonal Distrib.of larger Foraminifera of Kirthar Series", Rec.Geol.Surv.Ind., LIX, pp.130-131; Pl.I, figs.4-5.

Very common in the Kohat Shale is a form which seems to be related to Spin Tangi Nummulites just described as N.beaumonti, although it is rnally different, being smaller, and having a flattened or excavat- ustule at each pole, instead of being externally devoid of granules or pustules in the adult state. In the northern parts of the Kohat-Potwar n, both east and west of the Indus, this species is represented by smal- specimens than further south. Thus specimens from the Shekhan nullah age $4\frac{3}{4}$ by $2\frac{1}{4}$ mm. in size, the largest measuring 6.0 by 2.5 mm.; but imens collected at Bahadur Khel average $6\frac{1}{4}$ by $2\frac{3}{4}$ mm. in size, the larg- measuring 8.1 by 3.1 mm. The general average of all the forms is about y $2\frac{1}{2}$ mm., which is considerably less than the average size of the Spin i species; but the ratio of thickness to diameter is much same as in that species. The number of whorls in this Kohat Shale form es from 10 to 12 at 6 mm. diameter, and there are about 55 chambers in last whorl at that size; which facts agree with the Spin Tangi N.beau- i. As with the latter, there are 3 whorls in the outer half of a radius uring $2\frac{1}{2}$ mm. The marginal cord is similarly thin; the height of the bers equals about twice their length in the inner whorls, but only about and a half times their length in the outer ones; and the septa are al- straight, often nearly vertical at bottom and little recurved at top. these features indicate affinity; and so this Kohat Shale form, despite very distinctive external appearance, may possibly be a premutation of later true N.beaumonti. I certainly do not, however, feel justified in tifying it with the latter; and as I know of no other form to which it be referred, I propose to treat it as a new species and call it N.pin- i after my late colleague Mr.E.S.Pinfold of the Attock Oil Company.

Distribution. I have found N.pinfoldi in all exposures of the Kohat Shale in the Kohat-Potwar basin (Attock and Kohat dist- s), and it also appears in Mr.Pinfold's collections from Waziristan. y be a northern variety of the form called "N.beaumonti" by Nuttall; the latter shows no external polar pustule, and Nuttall unfortunately no meridian section which might reveal a buried pustule. Nuttall's is smaller than true N.beaumonti, and its distinction th from N.beaumonti and from N.pinfoldi is indicated by its distinctly re crowded spire, there being four whorls instead of three in the outer lf of a radius measuring $2\frac{1}{2}$ mm. N.pinfoldi occupies a somewhat intermed-te position between N.globulus Leymerie and N.beaumonti. For description the Indian representatives of N.globulus see my Thal paper (1927, pp.271 3; Pl.XX, figs.6-10).

Illustrations.

Fig.9. N.pinfoldi. HOLOTYPE. From the Kohat Shale in the Bhagwan Kas nullah. External view, magnified 4 times.

Figs.10 & 11. Two other specimens from the same locality. Externa view, magnified 4 times.

Fig.12. N.pinfoldi. From the Kohat Shale near Kohat. Equatorial section, magnified 8 times.

Fig.13. N.pinfoldi. From the Kohat Shale of the Bhagwan Kas nullah Meridian section of a small, stout specimen.

Fig.14. N.pinfoldi. From the Kohat Shale at Bahadur ~~xxx~~ Khel. Meridian section of a large specimen

Assilina papillata Nuttall.

(Figures 15 to 18)

(pars)

1879. Nummulites exponens Sowerby; Fedden, "Table showingdistribution of Sind fossils enumerated in Messrs.d'Archiac and Haime's Description des Animaux Fossiles de l'Inde," Mem.Geol.Surv. Ind., XVII, p.199.

1879. Nummulites granulosa d'Archiac (pars); Fedden, loc.cit.

1879. Nummulites spira Roissy (pars); Fedden, loc.cit.

1915. Assilina exponens (Sowerby) (pars); Dainelli, "L'Eocene Friulano", p.193; Pl.XXIV, figs.1,5,7, etc.

1926. Assilina papillata n.sp.; Nuttall, "Foraminifera of Middle and Lower Khirthar Series", Rec.Geol.Surv.Ind., LIX, pp.144-145; Pl.VI, figs.5-7.

This species, as found in Sind, has been well figured and described by tall. It is very common in the Kohat and Attock districts, and in Waz-stan. Its average diameter is about the same (17 mm.) in the north as i d, although specimens measuring 20 to 21 mm. are fairly common in the th, as against the maximum of 19 mm. reported in Sind, and the northern

s seem to be relatively thinner than those observed by Nuttall. These
minor matters; but I would amend Nuttall's description in one respect,
he says that the thickness of the test is practically the same at the
tre as at the periphery. In actual fact, the centre is nearly always
avated, as Nuttall's own external views indicate, and as meridian sec-
is clearly prove; for the whorls are evolute practically from the first.
s due to this evolute character that the marginal cord often shows so
inently, causing the species to be referred to A. spira. At other times
later whorl enfolds the marginal cord only of its predecessor, and the
e is then indicated by a depression as shown in Nuttall's **fig.7**. Equat
l sections show considerable variation, the spire being characteristic-
loose and irregular, while the spacing of the chambers is equally
nstant.

Distribution. According to Nuttall, this species appears in the upper part of the Middle Khirthar in Sind. In the north, it is common throughout the Upper Chharat beds (Kohat and Nummulite Shales) he Kohat-Potwar basin and Waziristan. I have also found it in collec-
s from Eastern Bengal (though not associated with N. beaumonti). When
ying the collections of the Geological Survey of India in Calcutta,
ng my last visit to India (1936), I found this species repeatedly oc-
ing among the original types of Fedden and T. Rupert Jones. Apparently
had variously referred members of it to "Nummulina granulosa" (Reg.
H.43/175 and H.43/176), "N. spira" (Reg. No. H.43/179), etc., while Jones
ed No. H.43/173 "N. complanata" though Fedden doubtfully referred the
to "N. exponens". It would seem, from his illustrations, that Dainelli
similarly referred members of this species to Assilina exponens, which
y mind is far less excusable than confusing them with A. spira.

Illustrations.

Fig.15. Assilina papillata. From the Kohat Shale near Kohat. External view, showing a specimen with exceptionally prominent marginal cord. Magnified 2 time

Fig.16. Another specimen from same locality as Fig.15. External view of specimen with less prominent cord, ~~XXXX~~ intermediate in type between Fig.15 and Nuttall Pl.6, fig.7. Magnified 2 times.

Fig.17. Assilina papillata. From the Kohat Shale near Kohat. Equatorial section, showing loose and irregular spire. Compare with Nuttall's Pl.6, fig.6. Magnified 4 times.

Fig.18. Assilina papillata. From the Kohat Shale near Kohat. Meridian section, not ~~XXXXXX~~ illustrated in previous works. Shows relative thinness of the test at the poles. Magnified 4 times.

Assilina rota n.sp.

(Figures 19 to 24)

In the upper levels of the Khirthar limestones at Spin Tangi, first ap- ing below the level at which N.beaumonti abounds but continuing into beds which contain N.beaumonti, I found many Assilines which differ mat- lly from A.papillata although they may be related to it. Their tests decidedly involute instead of being evolute, and as a consequence show rked polar thickening. Owing to the rapid increase in the width of the r chambers, coupled with the less involute nature of the outer whorls, test often shows a swollen rim as well as a central boss. This tends to the form a wheel-like appearance, for which reason I propose to call species A.rota. The involute nature of the test causes the surface ings to be much less prominent than those of A.papillata, but they ap- ntly follow the same arrangement as in that species. The equatorial ion shows a more regular and more closely wound spire than that of A. llata. There are about 12 whorls in a radius of 7 mm. The specimens ected average 13¾ by 2¾ mm. in size, the largest measuring 18.3 by 2.8mm.

Distribution. I have only seen this form at Spin Tangi in Baluchistan, and in the Sirki Shales of the Kohat district. Together Dictyoconoides kohaticus var.spintangiensis and Alveolina elliptica, it s to date the Sirki Shales as Upper Khirthar. The characters of the ies are not so well marked, however, in the Sirki Shales specimens as are in the Spin Tangi ones. The former, while sometimes characteristic gh, are on the whole less obviously distinct from A.papillata. This may cate the derivation of A.rota from A.papillata; and, together with the nce of N.beaumonti, it suggests that the Sirki Shales are slightly older the latest Spintangi levels.

Illustrations.

Fig.19. Assilina rota. HOLOTYPE. From upper levels of Khirthar limestones at Spin Tangi. External view. Magnified two times.

Figs.20 to 22. Three other specimens of same species from same locality as Fig.19. External view, magnified two times.

Fig.23. Assilina rota. From upper levels of Khirthar limestones at Spin Tangi. Equatorial section. Magnified 4 times.

Fig.24. Assilina rota. From upper levels of Khirthar limestones at Spin Tangi. Meridian section. Note the involute nature of the early whorls, causing the central thickening; and the rapidly increasing width of the spire, tending to produce a marginal thickening. Magnified 4 times.

Assilina shekhanensis n.sp.

(Figures 25 to 27)

1924. Assilina granulosa (d'Archiac); Davies, Journ.Asiat.Soc.Bengal? (N.S.), XX, p.213.

1925. Assilina granulosa (d'Archiac) (pars); Nuttall, Quart.Journn. Geol.Soc.Lond., LXXXI, p.443; Pl.XXVI, fig.2.

1937. Assilina cf.pustulosa Doncieux; Davies, Pal.Ind., (N.S.), XXIV, Mem.1, pp.34-35, 67; Pl.IV, figs.13-15,18,22.

When describing the Salt Range fauna, I provisionally referred this to Dr.Doncieux's species A.pustulosa; but I have since been given imens of A.pustulosa by Dr.Doncieux himself, and find that the Indian ies is quite distinct from his one, which is both smaller and relative-touter, and has an altogether different meridian section. It seems ssary, therefore, to treat the Indian form as a new species, and I pro- to call it A.shekhanensis after the Shekhan Limestone in which it most nds. I have little to add to the description of the form given in my Range memoir (1937), except to say that I have since found that it es considerably in size, presumably according to local conditions, for average specimen in one exposure of a bed may be larger than any seen nother outcrop of the same bed. Thus the average size varies from $6\frac{1}{2}$ $\frac{1}{4}$ mm. in some exposures to 10 by $1\frac{1}{2}$ mm. in others; the general average g $8\frac{1}{2}$ by $1\frac{1}{4}$ mm., and the largest specimen observed measuring 11.5 by mm. In all specimens the essential features are the same, and the ex-ely "wasp-waisted" appearance of the meridian section proves that the e is evolute from the first.

Distribution. This species characterises the upper levels of the Laki, appearing in the Ghazij Shales of Baluchistan and the rar beds of the Salt Range. It is the principal Assiline found in the han Limestone, or latest Laki formation in the Kohat-Potwar basin. It not seem to survive the Laki, although externally similar forms are to een in some exposures of the Kohat Shales. The latter are less excavat-t the poles, however, and are actually megalospheric forms. Their mic-heric companion, which must be far larger, has not yet been found by me, they do not seem to survive into the Nummulite Shale. These Kohat Shale s, which might be mistaken for A.shekhanensis, may possibly be derived the latter, but are not identifiable with it.

Illustrations.

Fig.25. Assilina shekhanensis. HOLOTYPE. From the Shekhan Limestone at Chikar Kot, near Kohat. External view. Magnified four times.

Fig.26. Assilina shekhanensis. From the Shekhan Limestone in the Shekhan nullah, Kohat. Equatorial section. Magnified eight times.

Fig.27. Assilina shekhanensis. From the Shekhan Limestone in the Shekhan nullah, Kohat. Meridian section. Magnified eight times.

Assilina subshekhanensis n.sp.

(Figures 28 to 32)

Accompanying A.shekhanensis, and obviously its megalospheric companion, a small form with excavated poles and prominent spines, which has a very stinctive appearance in thin sections of Shekhan Limestones. Its average ze is about 3 by 1 mm., the largest observed measuring 3.7 by 1.2 mm. protoconch is double and subequal, the diameter of each cell varying m 0.14 to 0.28 mm. in extreme cases, but averaging 0.2 mm. There are t over 5 whorls in specimens measuring 3.5 mm., the numbers of chambers the whorls respectively averaging 7:15:21:26:33, although the observed iations in numbers are respectively 6-7:13-17:19-24:21-28:31-35. The ginal cord is thin, and the chamber partitions are almost straight and lined forward at about 30 to 40 degrees to the radius.

Distribution. This form appears together with A.shekhanensis in practically all exposures in which I found the latter. I e never seen it appearing where the latter was not also present.

Illustrations.

Fig.28. Assilina subshekhanensis. HOLOTYPE. From the Shekhan Limestone at Chikar Kot, near Kohat. External view. Magnified four times.

Figs.29 & 30. Same species, from same locality, as Fig.28. External view. Magnified four times.

Fig.31. Assilina subshekhanensis. From the Shekhan Limestone at Chor Galli. Equatorial section. Magnified sixteen times.

Fig.32. Assilina subshekhanensis. From the Shekhan Limestone at Chor Galli. Meridian section. Magnified sixteen times.

Assilina tattaensis (d'Archiac & Haime).

(Figures 33 to 37)

1853. Operculina? sp.; Carter, ~~[illegible]~~ Ann. Mag.Nat.Hist., (2), XI, pp.167-168; Pl.VII, figs.3-4.

1855. Operculina tattaensis n.sp.; d'Archiac & Haime, "An.foss.Gr. Numm.Inde", p.347.

1857. Operculina? sp.; Carter, Journ.Bomb.Br.Roy.Asiat.Soc., V, p.131; Pl.II, figs.3-4.

1879. Nummulites spira Roissy, var.tattaensis d'Arch.& Haime; Fedden, Mem.Geol.Surv.Ind., XVII, p.198.

1925. Assilina granulosa d'Archiac (pars); Nuttall, Quart.Journ.Geol. Soc.Lond., LXXXI, p.443; Pl.XXVI, figs.3-4.

1926. Assilina granulosa d'Archiac (pars); Nuttall, Rec.Geol.Surv. Ind., LIX, p.125.

Carter long ago described as an Operculine an Assiline which he found what Nuttall has since reported to be Meting Limestone (Lower Laki) beds r the village of Tatta in Sind. Messrs.d'Archiac and Haime subsequently erred to Carter's description and figures, and called the form O.tatta-is, while remarking on its relatively closely-wound spire which affili-d it to the Assilines. It has since been affiliated with A.spira by den and A.granulosa by Nuttall. It is certain that Fedden was wrong. doubtless arrived at his mistake by first confusing A.papillata with pira, and then [illegible] this species with A.papillata. the same time, the term A.granulosa has of late become so excessively holic that it has ceased to serve any exact stratigraphic purpose; so I e recently felt compelled to confine its application to the forms which t exactly correspond with those to which it was originally applied, giv-other designations to slightly different forms which actually character-somewhat different horizons. Whether or not these differences represent limits of zoological species, nobody can say. The species of the palae-ologist are based on more limited information than those of the zoolo-t, and are directed to other ends - primarily stratigraphic, with a view elucidating the contemporaneity of deposits, and hence the details of aeogeography and orogenic sequence. The palaeontologist cannot allow ies to be confused with physiological speculations. His objective cri-ia are purely morphological, and by them he must abide. Hence, owing to elimination of forms not exactly corresponding with the original types A.granulosa, the old species A.tattaensis again emerges as a type deserv-separate recognition; and as such it is here proposed to treat it.

The original material on which this species was founded being in Car-'s collections, I referred to the latter, and have selected what seems be the best-preserved remaining specimen, referred to this species by ter himself, to serve as lectotype. It is shown below as fig.33. Simi-specimens were found by me in the Kohat district. The Kohat form is ier larger than Carter's, although overlap occurs, some specimens from at seeming to be indistinguishable from Carter's specimens. The Kohat cimens average 14 by $1\frac{1}{2}$ mm. in size, the largest observed measuring 16.6 .4 mm. There are about 10 whorls in a radius of 7 mm., with about 60 mbers in the outermost whorl. The height of the chambers equals from e to three times their length, the relative height being actually ater in the outer whorls than in the inner ones. The chamber partitions for the most part vertical, straight, but boldly recurved in their up-ost quarter. There is often a small granular boss at the pole, and the ta and cord are also granulated; but the whorls are non-enveloping almost the first, except that the cord itself is sometimes enfolded by the eeding whorl - which tends to produce a depression along the course of spire.

Distribution. The species seems to characterise a fairly low Laki level in Sind. It is very abundant in an outcrop of Laki beds mile 40 on the Kohat-Thal road. The position of this outcrop is uncer-; it may be older than the Shekhan Limestone, since I found no A.shensis in it. On the other hand, A. tattaensis does survive into the an Limestone level, since I found a few representatives of it in the an Limestone outcrops, abounding with A. shekhanensis, at Chikar ear Kohat.

Illustrations.

Fig.33. Assilina tattaensis (d'Archiac & Haime). LECTOTYPE. Specimen No.P.33143, in the Carter collections at the British Museum (Nat.Hist.) in London. External view. Magnified three times.

Fig.34. Assilina tattaensis. Laki outcrop, near Mile 40, Kohat-Thal road. External view. Magnified three times

Fig.35. As Fig.34; large specimen from same outcrop. External view. Magnified three times.

Fig.36. Assilina tattaensis. Laki outcrop, near Mile 40, Kohat-Thal road. Equatorial section. Magnified four times.

Fig.37. As Fig.36, but Meridian section. Magnified four times.

Discocyclina thalica n.sp.

(Figures 38 to 40)

n the Lower Ranikot sandstones and shales of Kurram Picquet hill at I found a number of very small lenticular microspheric and megalo-ic Discocyclines which obviously constitute a pair. The microspheric which I propose to call D. thalica, measures about 3 by 1 mm.; the st observed measures 3.25 by 1.1 mm. It is covered with pillars, increase in thickness while passing from the equatorial layer to the ior, where they measure from 0.06 to 0.12 mm. in diameter; the thick-eing near the poles. The equatorial layer of chambers is about 0.04 hick, and the chambers measure about 0.03 by 0.035 mm. at 1 mm. from entre; the cyclical rings are about 0.035 mm. in height at that dist- Rosettes surrounding pillars are formed by 6 to 8 radiating vertical s; lateral sections show networks of lines resembling a honeycomb, of the irregular polygonal cells are about 0.3 to 0.6 mm. in diameter. difficult to deal with the species, owing to its small size. I wish cord it, however, since it is the earliest true Discocycline to appear dian beds. The large and well developed D. ranikotensis first appears slightly higher level.

istribution. I have only seen this form in the Lower Ranikot beds at Thal.

Illustrations.

Fig.38. Discocyclina thalica. HOLOTYPE. Specimen from Lower Ran-

ikot beds of Kurram Picquet hill. External view. Magnified eight times.

Fig.39. Discocyclina thalica. From same locality as Fig.38. Equatorial section. Magnified twentyfour times.

Fig.40. Discocyclina thalica. From same locality as Fig.38. Meridian section. Magnified twentyfour times.

Discocyclina subthalica n.sp.

(Figures 41 to 43)

This is the megalospheric companion of D.thalica, and not much smaller, averaging about 2 by $\frac{3}{4}$ mm. in size. The largest observed measures by 0.8 mm. Its external characters are similar to those of D.thalica. test is lenticular, and the pillars are from 0.06 to 0.08 mm. thick. equatorial layer of chambers is about 0.035 mm. thick near the proto-ch, and 0.055 mm. thick near the periphery. The protoconch is double; smaller cell, measuring about 0.10 to 0.12 mm., is almost completely rounded by the larger, measuring about 0.20 to 0.24 mm. The equatorial gs are from 0.03 to 0.05 mm. in height, and the chambers into which they subdivided are practically square, the tangential measurement being tle less than the radial. Rosettes etc. are as described for D.thalica.

Distribution. I found this form together with D.thalica in the Lower Ranikot beds at Thal, and also identified it in sections Upper Ranikot limestones outcropping 20 miles east of Thal.

Illustrations.

Fig.41. Discocyclina subthalica. HOLOTYPE. Specimen from Lower Ranikot beds of Kurram Picquet hill. External view. Magnified eight times.

Fig.42. Discocyclina subthalica. From same locality as Fig.41. Equatorial section. Magnified twentyfour times.

Fig.43. Discocyclina subthalica. From same locality as Fig.41. Meridian section. Magnified twentyfour times.

Alveolina ellipsoidalis Schwager.

(Figures 44 to 48)

1883. Alveolina ellipsoidalis n.sp. (pars); Schwager, Palaeontographica, XXX, pp.96-98; Pl.XXV, figs.2,a-c.

1938. Alveolina elliptica (Sowerby); Silvestri, Palaeontographia Italica, XXXII, Suppl.3, Pt.IV, pp.53-54; Pl.III, fig.2; Pl.XII, figs.1-8.

In the Upper Ranikot beds at Thal, and in Mr.Pinfold's collections from e Upper Ranikot beds of Waziristan, appears a small ovoid Alveoline which relatively stouter than A.vredenburgi, which it sometimes accompanies; l internal sections show that its whorls are less crowded than those of at species, and its chamberlets much larger. Its whole internal aspect much coarser. The average size is about $2\frac{1}{2}$ by $1\frac{1}{2}$ mm., the largest seen asuring 3.0 by 1.88 mm. The protoconch averages 0.12 mm. in diameter, rying from 0.10 to 0.14 mm. There are 9 to 10 whorls in specimens of $1\frac{1}{2}$ diameter; about 5 major chambers; and 12 to 16 chamberlets per 1 mm. in outer whorls. There is no trace of flosculinisation, but the structure the test is thick throughout. So far as I have seen, the already describ form which matches it the most closely is one of Schwager's illustrations A.ellipsoidalis, which shows a specimen $2\frac{1}{2}$ by $1\frac{1}{2}$ mm. in diameter, with toconch measuring 0.07 mm. in diameter, about 10 whorls, six major chams, and 13 cells per 1 mm. in the outer whorl. The same may either be a ng representative, or the megalospheric companion, of the much larger m with smaller protoconch also figured by him. In the meantime, I proionally refer this Ranikot species to Schwager's A.ellipsoidalis.

Distribution. As noted above, this species has only been seen hitherto in the Upper Ranikot beds of the Kohat district and Waziran, in the Indian region. If rightly identified with A.ellipsoidalis, it o appears at a rather higher level (Lybian, or Lower Eocene beds, approxtely corresponding with the Indian Laki formation) of the Egyptian region Silvestri has recently figured a very similar form, measuring about 2.5 1.9 mm., which appears in what is supposed to be an erratic block of Creeous age in Somaliland. Its protoconch varies from 0.13 to 0.23 mm. in e, and it has about 9 whorls and from 12 to 16 chamberlets per 1 mm. in outer whorls. I cannot understand how this veteran worker could have erred this diminutive species to Sowerby's much larger, later, and totalifferent A.elliptica. There is no sort of resemblance between the two ns. On the other hand, the most material difference between Silvestri's n and my Ranikot one lies in the fact that his is less elongate, and s less thickening of the spiral layers towards the poles; but both of se differences may be due to the imperfect orientation of his sections. ny case, the affinity between the possibly Mesozoic Somaliland form and undoubtedly Paleocene (Upper Ranikot) Indian one indicates the antiquity he type. The nearest known Indian equivalent of the latter is the litearly Laki species which was referred to A.lepidula by Nuttall in 1925, by myself in 1938 (Nature, 29/1/1938, p.202). But A.lepidula is a micheric form, and has smaller chamberlets than the Upper Ranikot species.

Illustrations.

Figs.44 to 46. Alveolina ellipsoidalis. From Upper Ranikot beds at Thal. External view. Magnified eight times.

Fig.47. Alveolina ellipsoidalis. From Upper Ranikot beds 2 miles north of Khajuri, Waziristan. External view. Magnified eight times.

Fig.48. Alveolina ellipsoidalis. From Upper Ranikot beds 2 miles north of Khajuri, Waziristan. External view. Magnified eight times.

Alveolina vredenburgi Davies.

(Figures 49 and 50)

1925. Alveolina oblonga d'Orbigny (pars); Nuttall, Quart.Journ.Geol. Soc.Lond., LXXXI, p.441.

1926. Alveolina oblonga d'Orbigny (pars); Doncieux, Ann.Univ.Lyon, N.S., I, fasc.45, p.76; Pl.VIII, fig.2.

1926. Alveolina oblonga d'Orbigny; Cotter, Rec.Geol.Surv.Ind., LIX, p.415.

1926. Alveolina oblonga d'Orbigny (pars); Nuttall, Geol.Mag.Lond., LXIII, pp.498-500.

1927. Alveolina oblonga d'Orbigny; Davies, Quart.Journ.Geol.Soc.Lond., LXXXIII, pp.282-283 & Text-fig.5.

1931. Alveolina oblonga d'Orbigny; Nuttall, Rec.Geol.Surv.Ind., LXV, pp.310,312.

1937. Alveolina vredenburgi N.sp.; Davies, Pal.Ind., N.S., XXIV, Mem. 1, pp.57-58,67; Pl.V, fig.25.

I recently described this form as a new species, in order to distinguish from A.oblonga to which it had previously been referred, but from which I become convinced that it should be separated. Further work on it has firmed this opinion, but has brought out facts which necessitate a revis- description of the species. Owing to the fragile nature of the test, it been very difficult to obtain good internal sections of it; but continue has shown that it is very variable, and that later Ranikot specimens m among which the holotype was chosen) usually differ from earlier Rani- ones in possessing a more crowded spire, with more numerous whorls, and more chambers per 1 mm. in the outermost whorl, at similar diameters. meridian section of a Lower Ranikot specimen from Thal was shown in -fig.5 on p.282 of my 1927 paper (cited above). I also showed, in the e on p.283 of the same, that the spire was more crowded, with more num- s chamberlets, in the uppermost Ranikot beds at Thal itself. In the Range Ranikot beds, some of which are younger than the Thal ones, these encies become still more marked. A meridian section of a late Ranikot cimen, of similar horizon to the holotype, is now shown below (Fig.50). ould now redescribe the species as follows:

The ratio of diameter to axial length varies from over ½ to less than The longest specimen seen measured 6.5 by 1.5 mm.; but the usual lengt under 4 mm., average measurements of observed specimens being about 3¾ 1½ mm. The shape varies from cylindrical with rounded ends to very ngate with pointed ends, most specimens being distinctly fusiform. Lat Ranikot specimens are usually larger than earlier Ranikot ones, and hav e whorls, and more crowded chamberlets, at similar diameters.

Upper Ranikot. The number of whorls is about 20 for a diameter of 1.5 , with about 17 to 27 chamberlets per 1 mm. in the outermost whorls, ut 25 to 35 per 1 mm. at 0.5 mm. radius, and from 30 to 40 per 1 mm. in earliest whorls. The later whorls exhibit from 6 to 8 major chambers. protoconch is double, the larger cell varying from 100 to 150 μ in diam r, and the smaller cell having a diameter of about 40 μ.

Lower Ranikot. The average size is about 2½ by 1¼ mm., the largest ob ved measuring 3.5 by 1.8 mm. The number of whorls is about 8 for a di- ter of 1 mm., with 13 to 15 chamberlets per 1 mm. in the outermost whor

Distribution. The Lower Ranikot forms were found by me in the outcrop of Kurram Picquet hill, where they accompany D.thalica D.subthalica, N.wadiai, etc. The Upper Ranikot forms appear in the er levels of the Khairabad Limestone, or equivalent horizons elsewhere, north-west India, and are found in various outcrops at all levels of th ala Shales (i.e. to the end of Ranikot times).

Illustrations.

Fig.49. Alveolina vredenburgi. HOLOTYPE (G.S.I.Type No.15895). From the Patala Shales at Makarwal, western Sal Range. External view. Magnified eight times.

Fig.50. Alveolina vredenburgi. From the Patala Shales near Kalabagh, western Salt Range. Meridian section. Magnified eight times.

Alveolina violae Checchia-Rispoli.

(Figures 51 to 53)

1878. Alveolina oblonga d'Orbigny; Marinoni, Atti della Soc.Ital.di Sc.Natur, XXI, p.660.

1882. Alveolina oblonga d'Orbigny; Taramelli, Atti della R.Accad.dei Lincei, (3), XIII, p.465.

1905. Alveolina Violae n.sp.; Checchia-Rispoli, Palaeont.Italica, XI, pp.165-167; Pl.II, figs.5-10.

1909. Alveolina granum festucae Bosc., var.elongata d'Orbigny (pars); Osimo, Palaeont.Italica, XV, pp.87-88; Pl.V, figs.32,34.

1915. Alveolina Violae Checchia-Rispoli (pars); Dainelli, 'L'Eocene Friulano,' pp.166-167; Pl.XVI, fig.8; Pl.XVII, fig.5; Pl.XVIII, figs.1-5.

There appears, in the Middle Khirthar beds of the Kohat-Potwar basin, an ngated Alveoline whose presence has not hitherto been noted in India. It much too long to be identified with A.oblonga, and much too slender in portion to its length to be identified either with A.javana or A.ellipti- Its nearest equivalents are A.violae, and the two forms (A.elongata rbigny and A.frumentiformis Schwager) which are hardly distinguishable n A.violae. Those two, however, are more fusiform than the Indian spe- s, whose usually blunted ends agree best with the similarly blunted ends A.violae. It was, indeed, its rod-like shape which caused A.violae to be erred by earlier writers to A.oblonga, until Checchia-Rispoli rightly arated it on account of its much greater relative and absolute length.

The Indian form averages about 11¼ by 2¼ mm. in size, although specimens e been seen measuring up to 16 by 3 mm., which is the normal size men- ned by Dainelli for this species in Europe. The protoconch is double, smaller cell measuring 0.10 to 0.15 mm., and the larger (which encloses 0.20 to 0.40 mm. in diameter. It has from 11 to 14 (usually about 12) ls at 2 mm. diameter, and about 8 major chambers at the same. The num- of chamberlets is about 14 to 15 per 1 mm. at 2 mm. diameter. There is le or no flosculinisation in the middle of the test, but considerable kening towards the poles gives it its rather cylindrical appearance.

The species is thus rather smaller than A.violae as figured and describ- rom the Middle Eocene of Friuli; the latter apparently averaging about y 3 mm. in size, and having 14 to 15 major chambers, 14 to 20 whorls, 13 to 16 chamberlets per 1 mm. in the outer whorls. But the differences fly consist in the presence of more whorls and major chambers, and may ue to the correspondingly greater size of the type form, whose proto- h is also rather larger, the big cell measuring 0.35 to 0.55 mm. I do think it justifiable to separate the Indian form on this account, and provisionally refer it to the same species.

Distribution. Very common in the Kohat Shale, but also locally abundant in the Nummulite Shale and Kohat Limestones of the Kohat- ar basin. I have not yet seen it in any but Middle Khirthar beds.

Illustrations.

Figs.51 & 52. Alveolina violae. From the Kohat Shales, Thal. Meridian sections. Magnified eight times.

Fig.53. Alveolina violae. From the Kohat Shales, Thal. Equatorial section. Magnified eight times.

Illustrations.

Figs.51 & 52. Alveolina violae. From the Kohat Shales, Thal. Meridian sections. Magnified eight times.

Fig.53. **Alveolina violae.** From the Kohat Shales, Thal. Equatorial section. Magnified eight times.

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8. General Remarks.

I attach herewith six Text-figures (prepared separately from the text), plates showing the palaeontological Figures (1 to 24 and 25 to 53 re- ctively) quoted above, the Legend for my map, and a sheet showing two tions of north-western Kohat district beds for comparison with the two ures given by Wynne which are reproduced alongside.

Wynne quotes no scale for his sections, and their vertical proportions obviously much exaggerated. These two old sections of his still repre- t the only ones hitherto prepared, apart from my own, of the portions of Kohat district mapped by myself (for the area concerned, see Test-fig.1). own previous sections of beds within this newly mapped area were publish- in my Kohat (1924) and Thal (1927) papers, and the Samana memoir (1930).

The two sections now shown represent the same ground (as nearly as it d be identified) as is represented by Wynne's figures. Wynne had no e-scale topographical map to work on, and his first section, extending the Kohat Towi river to the highest peak to south of it a few miles of Hangu, probably does not represent such a straight line as my cor- onding section does. This may explain certain discrepancies in the con- s. At the same time, the general line taken by his section cannot be different from that taken by mine; so it is certain that Wynne's beds, h he regarded as successive, were really repetitions of the same very ted series. Thus his beds numbered 2, 6, 10 and 12 were undoubtedly essive outcrops of the Kohat Limestones, with Chharat beds at their ; while his number 7 is undoubtedly (vide his text, p.107) the broad rop of Lower Chharat conglomerate which appears about midway between river and the peak. It will be seen from my section that this outcrop ally dips to the north, instead of to the south as shown by Wynne. Per- the ground to south of it was obscured by detritus where he crossed, he may have mistaken joint planes for dip slopes. My own continuous ing of the area made any such mistake impossible. The hasty nature of e's survey made it impossible for him to check his first impressions, h were all that he could record.

As regards the Darsamand section (Wynne's and my second figure) I found lear evidence of a fault where Wynne shows one on the southern flank of mountain. What he saw was probably the outcrop of the Belemnite bed e in places vertical) with sandstones to south of it obscured by detrit- The underlying limestones are, however, conformable, as continuous map- shows. Wynne probably never went over the northern slopes of the tain, about which he was obviously doubtful (I myself could only visit with an armed escort, and did so against the protests of the local tical Officer). So Wynne did not realise that Eocene beds appear there tly as they do on the southern flank.

N.B. By "Sabathu" beds, on his Fig.1, Wynne meant (in the terminology of his day) representatives of the later parts of the Indian Nummu-c sequence. The term, although still employed (like the equally vague ession "Hill limestone") by those who cannot trust themselves to define in terms of standard modern stratigraphy, has no exact stratigraphic e. Its use by Wynne was excusable and inevitable; but its continued today is simply an evidence of incapacity. It is noticeable that Wynne not apply the term "Sabathu" to the Eocene beds on the southern flank he Darsamand mountain. Those beds are actually as old as the oldest ne known in Sind. Wynne could not have proved that fact, which has been established by my own recent work on Ranikot foraminiferal faunas; he had the palaeontological instinct to sense what he could not prove. age 110 of his paper Wynne remarks on the "older aspect" of Eocene forms hal, where I first established the presence of Ranikot beds. Those s were quite unknown in Wynne's day, but he had the genius to recognise both as Eocene and as early Eocene, although he had never seen them re.

Acknowledgments.

As already indicated, I am indebted to the Attock Oil Company for facil-s in examining their sections east of the Indus, for comparison with ions in the Kohat district, and so obtaining a better conception of the t-Potwar basin as a whole. This is important, since that basin formed efinite a unit during Eocene times. I am indebted to the Carnegie Trust the Universities of Scotland for a grant in aid towards the expense of ate visit to India, and to the Director of the Geological Survey of Ind-or access to the Survey collections in Calcutta. I am much indebted to .M.Craig of the Department of Geology, of the University of Edinburgh, assistance in photographing the sections of foraminifera shown in con-ion with the palaeontological part of this paper.

Bibliography.

This paper is largely based upon my previously published works, which up to it, and which it serves to coordinate and complete. This applies articular to my Salt Range memoir, published last year (1937). That ir, together with this paper, represents the post-graduation portion of tudies; and it adds considerably to pre-existing knowledge of Ranikot Laki species, thus helping to fill the gaps in our knowledge of Indian ne faunas where those gaps had been most pronounced. It was largely g to this improved knowledge of the earlier Eocene forms that I was to distinguish any local Eocene stage practically at sight, when I rned to the field in 1935-1936, and completed the mapping of Eocene rops over an area more than 1,000 square miles in extent, before my s gave out.

Under the circumstances, since the Salt Range memoir also represents t-graduate work to the same end as this paper, and the bibliographies both papers have so much in common, I have decided not to repeat the ge bibliography quoted in that memoir, but to quote only those additiona ks (themselves only a selection) which have principally to do with this er. The following, therefore, only indicates those works in addition to ones quoted in the Salt Range memoir (pages 75 to 79) which are referre directly or indirectly in this paper. Both bibliographies should be tak as applying to this paper.

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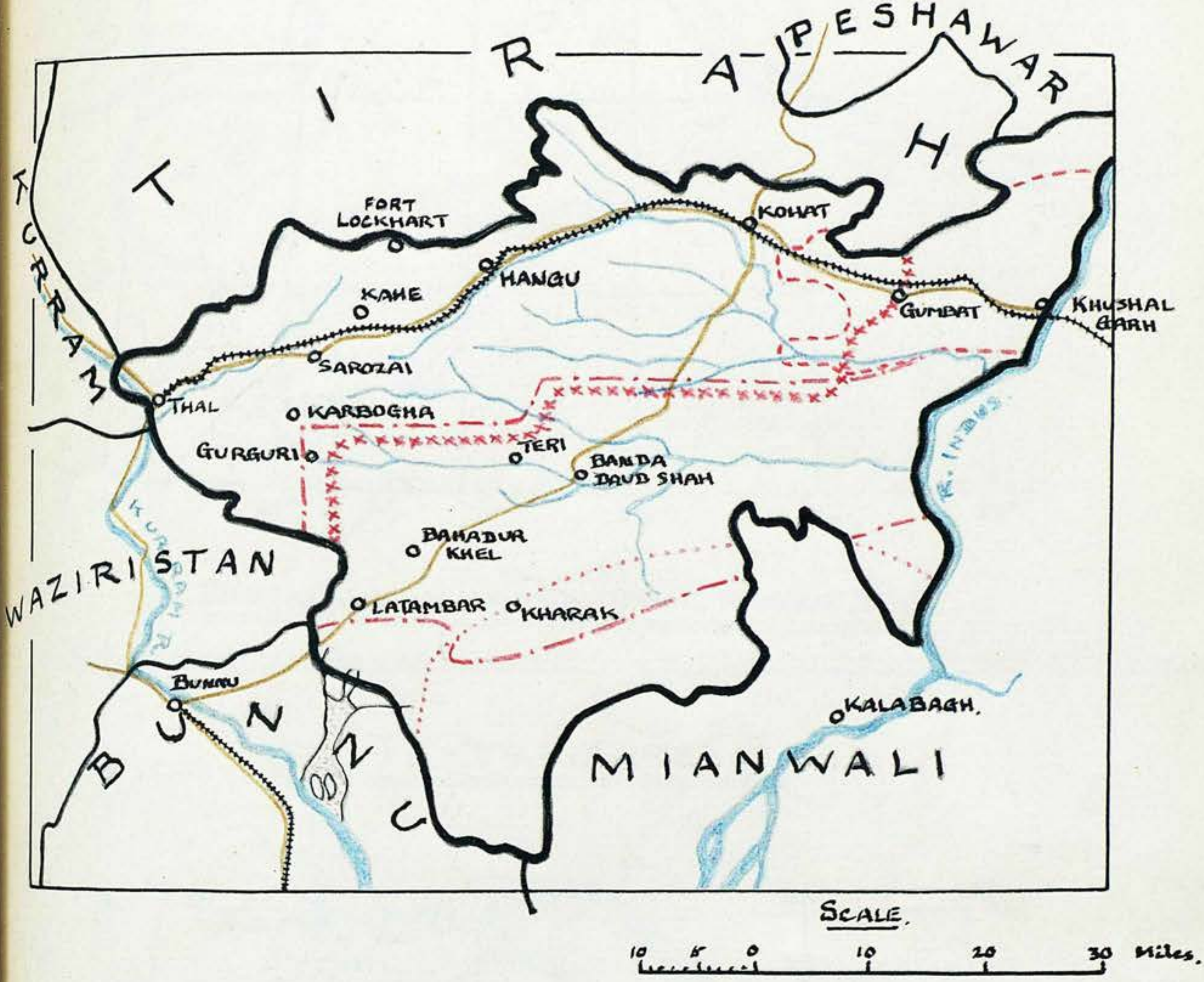
TEXT-FIGURES 1-6.

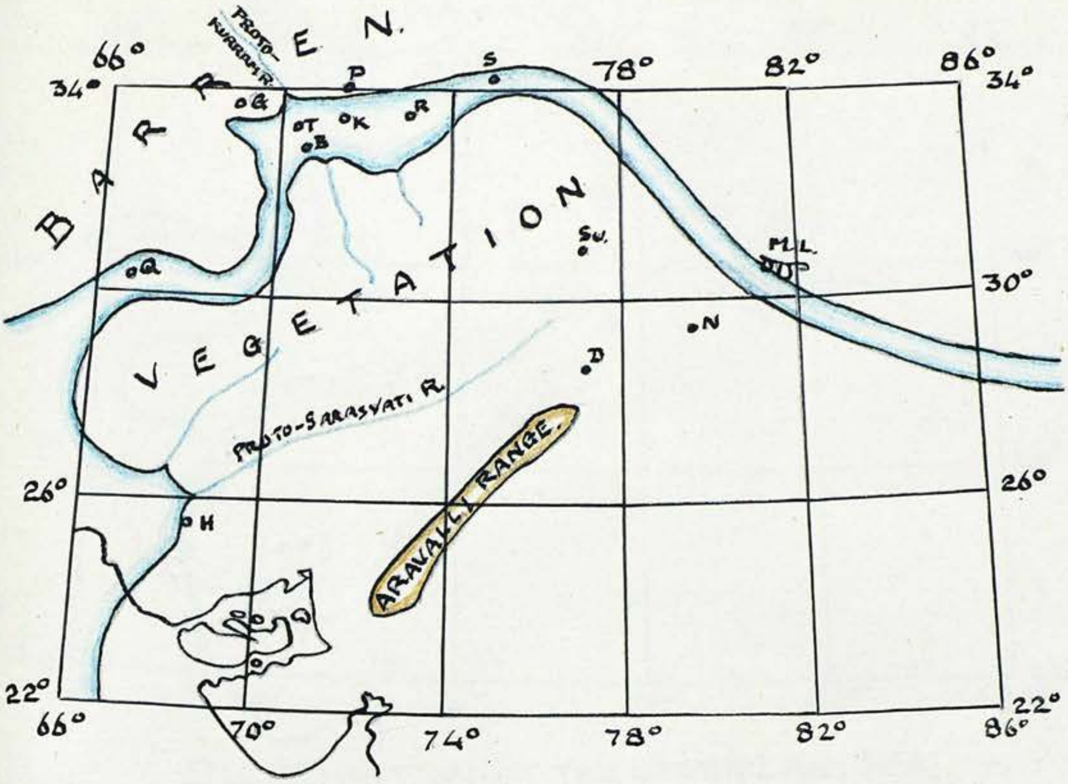
TEXT-FIGURE 1.



Borders of Kohat district.
" " other districts.
Roads.
Railways.
Rivers.
Area mapped by Wynne, 1875.
" " " " 1880 (northern limits).
" " " Attock Oil Company (northern, western and southern limits).
" " " myself, 1935-1936 (Southern and eastern limits. Overlaps Wynne's 1875 map to south, and A.O.C. map to east, and extends to northern and western borders of the Kohat district).

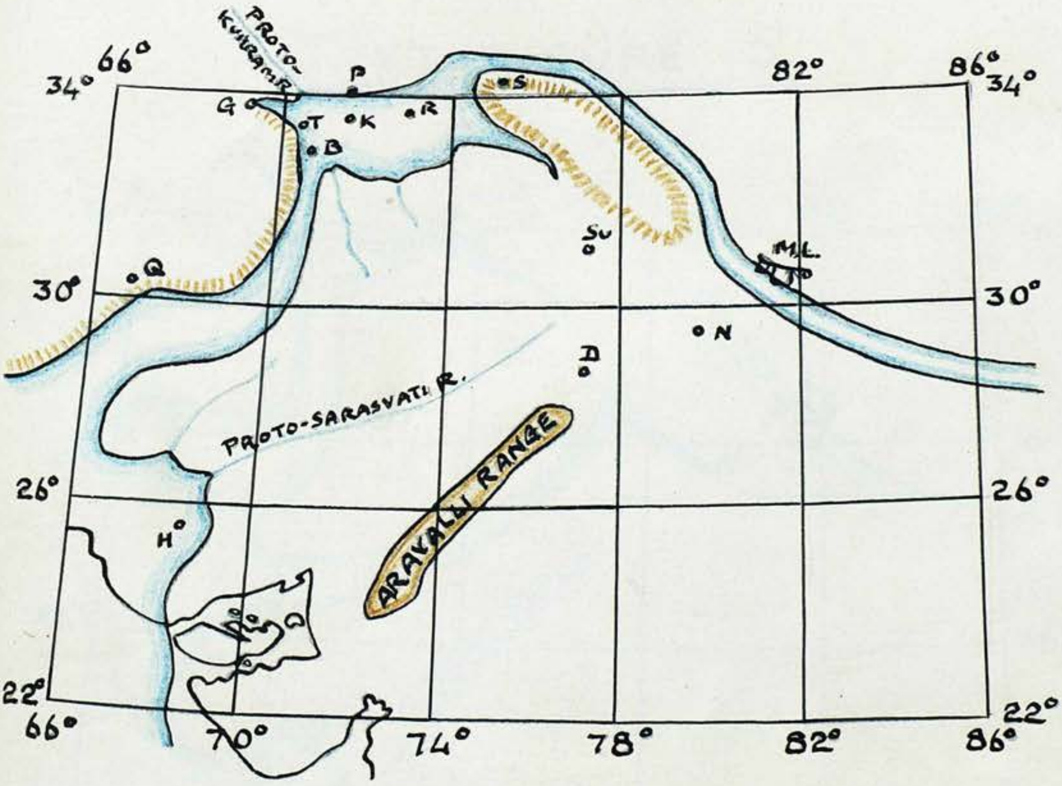
The attached Map, at 1" = 1 Mile, combines the area mapped by myself (west of Gumbat) with the area mapped by the A.O.C. (east of Gumbat) in order to give a complete supplement to Wynne's maps of the southern half of the Kohat district.

TEXT-FIGURE 2.



DISTRIBUTION OF THE UPPER RANIKOT SEA.

TEXT-FIGURE 3.

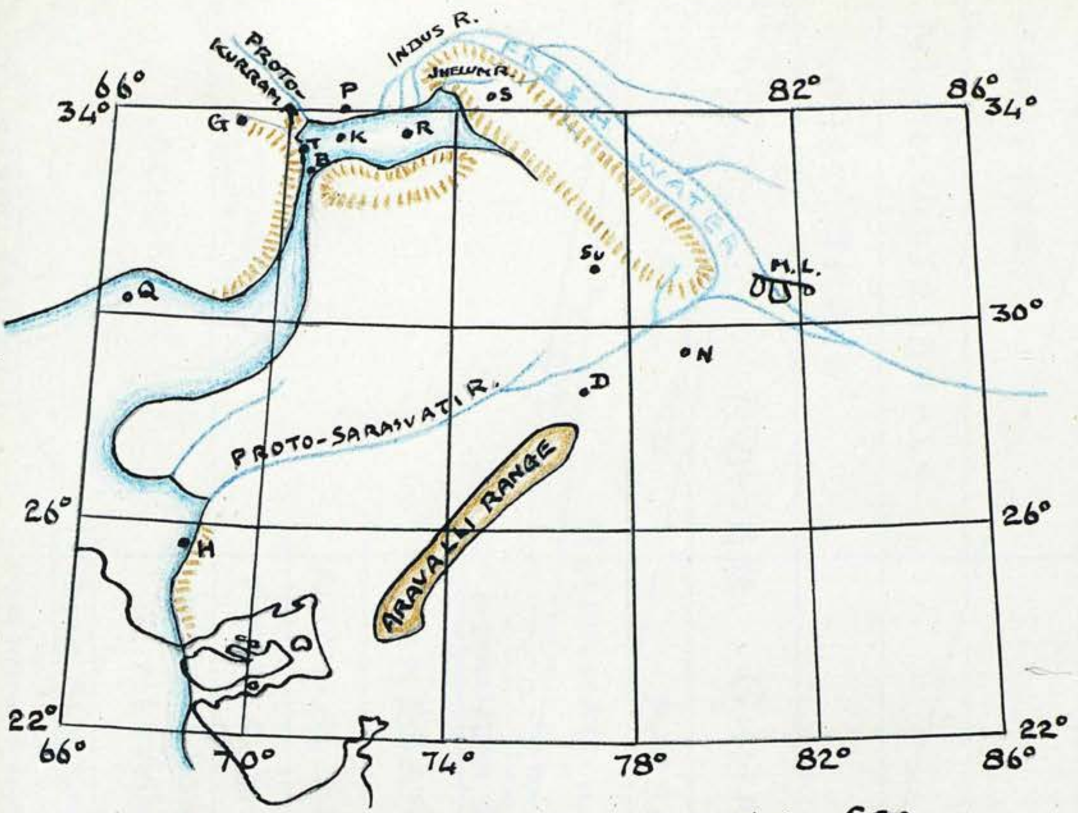


DISTRIBUTION OF THE LOWER LAKI SEA.

NOTE: INITIAL EMERGENCE OF NORTH-WEST HIMALAYAN AXIS.
FURTHER EMERGENCE OF NORTHERN AFGHANISTAN.

B = BUNNU	K = KOHAT	Q = QUETTA.
D = DELHI	M.L. = MANASAROWAR LAKES.	R = RAWALPINDI.
G = GARDEZ	N = NAINI TAL.	S = SIRINAGAR.
H = HAIDERABAD (SIND).	P = PESHAWAR.	Su = SUBATHU.
		T = THAL.

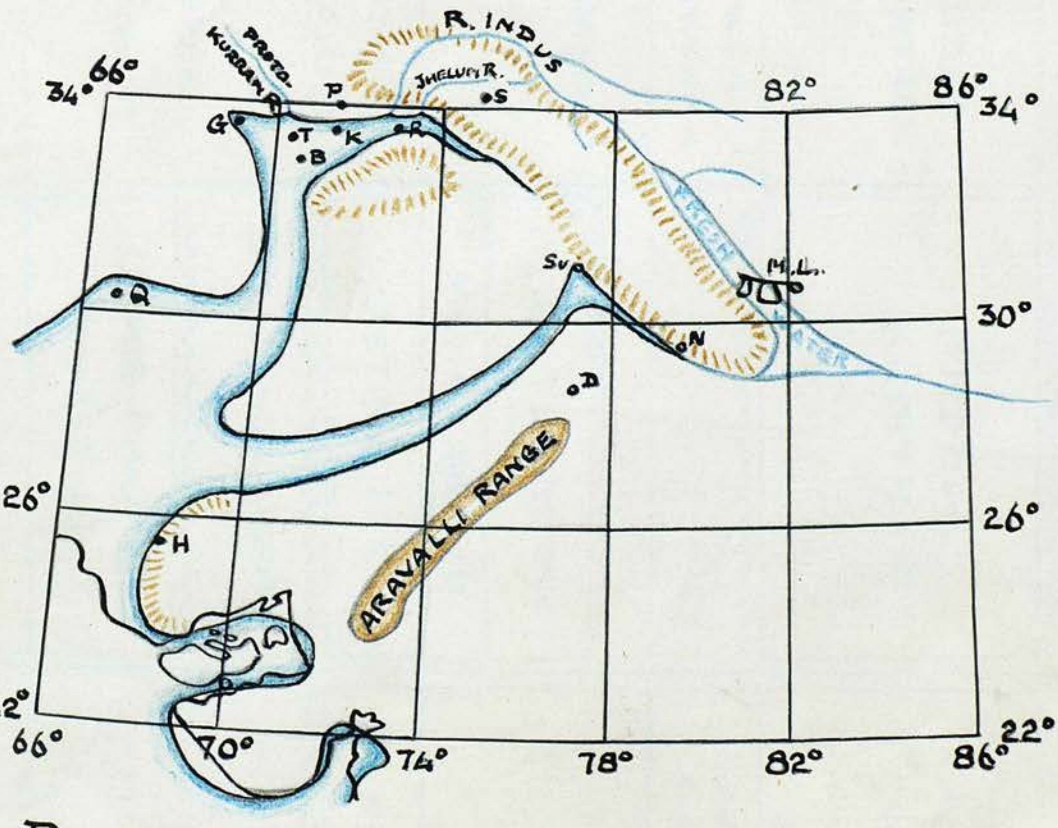
TEXT-FIGURE 4.



DISTRIBUTION OF THE UPPER LAKI SEA.

NOTE: SEVERANCE OF THE TRANS-HIMALAYAN ESTUARY.
PONDING OF TRANS-HIMALAYAN DRAINAGE, AND GENESIS OF UPPER INDUS AND JHELUM RIVERS, ETC.
INITIAL EMERGENCE OF SALT RANGE AXIS.
CONSEQUENT DESICCATION OF KOHAT-POTWAR BASIN.

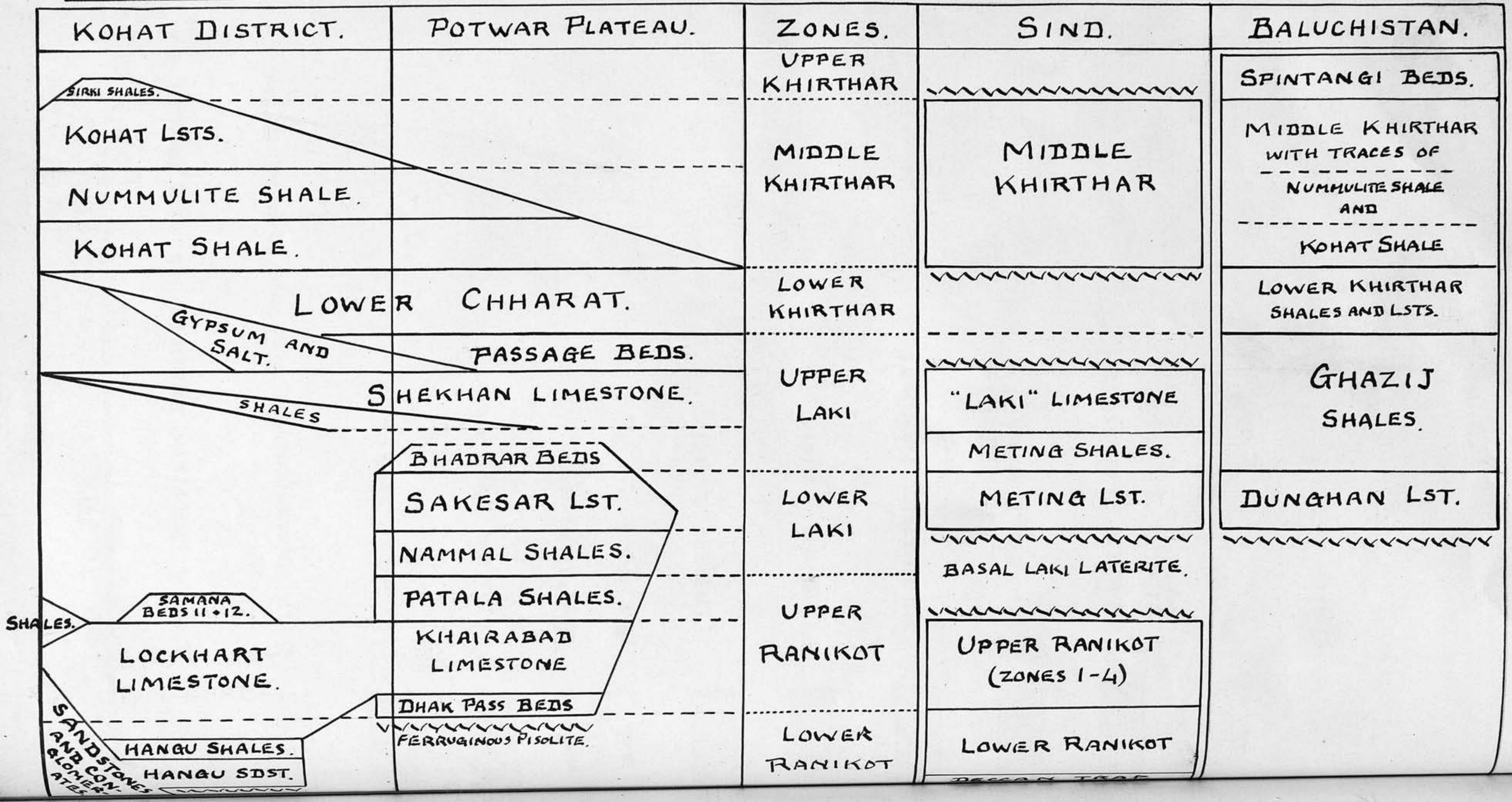
TEXT-FIGURE 5.



DISTRIBUTION OF THE MIDDLE KHIRTHAR SEA.

NOTE: ESTABLISHMENT OF UPPER INDUS RIVER.
WESTWARD MOVEMENT OF NORTHERN MARINE WATERS.
TEMPORARY MARINE INVASION OF RAJPUTANA.
APPROXIMATION TO PRESENT KATHIAWAR COAST-LINE.

TEXT-FIGURE 6: CORRELATION TABLE OF KOHAT DISTRICT EOCENE BEDS.



LEGEND TO MAP OF KOHAT DISTRICT

UPPER TERTIARY SANDSTONES AND SHALES.

SIRKI SHALES, KOHAT LSTS. AND NUMMULITE SHALE.

KOHAT SHALE.

LOWER CHHARAT.

G GYPSUM.

S SALT.

UPPER LAKI.

LOWER LAKI.

PROBABLY RANIKOT.

UPPER RANIKOT.

LOWER RANIKOT.

MESOZOIC.

Figures 1-8: <u>Nummulites beaumonti</u> d'Arch.& Haime. (Text, pp.38-41.)

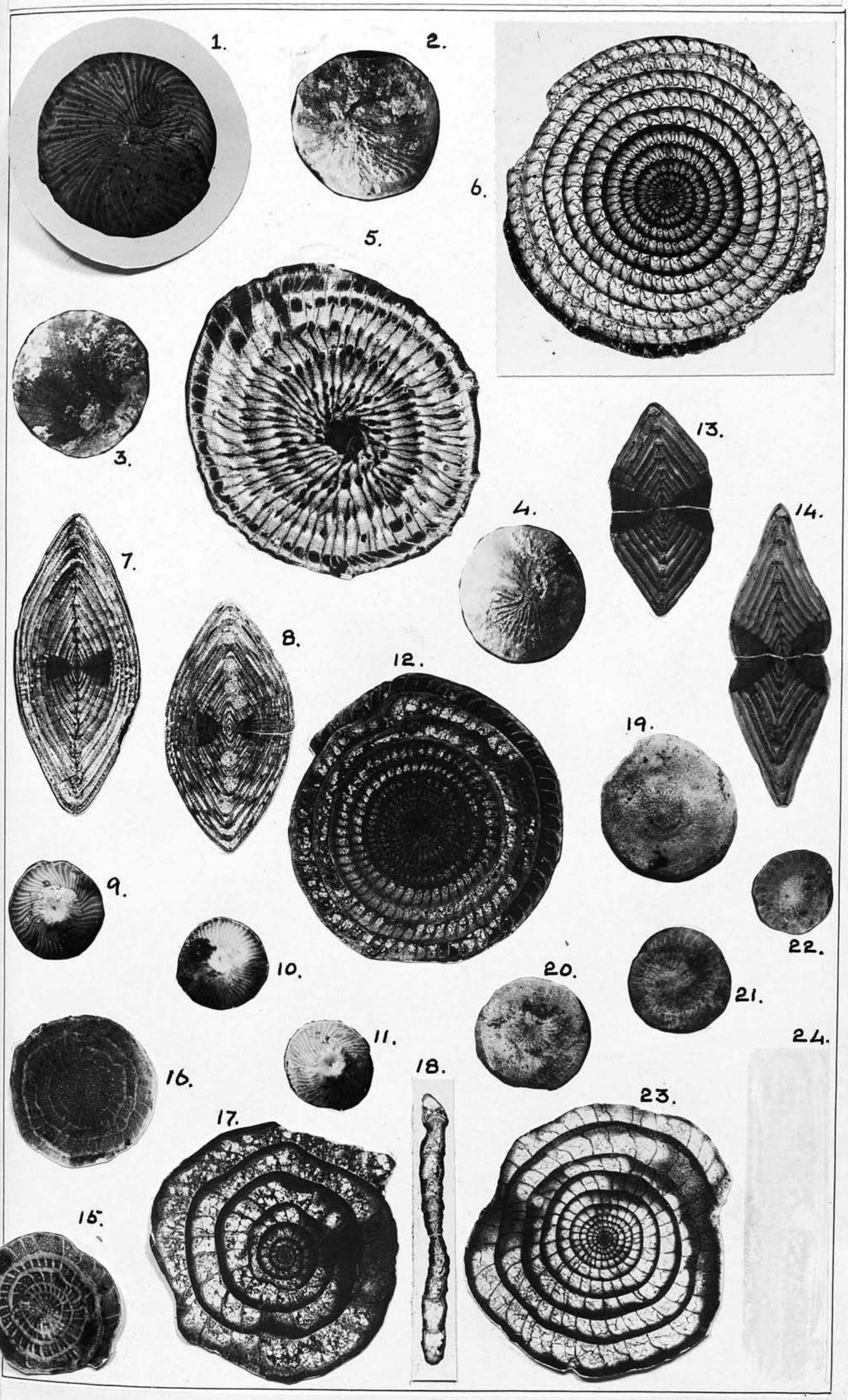
Figures 9-14: <u>Nummulites pinfoldi</u> n.sp. (Text, pp.42-43.)

Figures 15-18: <u>Assilina papillata</u> Nuttall. (Text, pp.43-44.)

Figures 19-24: <u>Assilina rota</u> n.sp. (Text, p.45.)

ILLUSTRATIONS.

FIGS. 1 TO 24.



NUMMULITES AND ASSILINES.

Figures 25-27: Assilina shekhanensis n.sp. (Text, p.46.)

Figures 28-32: Assilina subshekhanensis n.sp. (Text, p.47.)

Figures 33-37: Assilina tattaensis (d'Arch.& Haime). (Text, pp.47-49.)

Figures 38-40: Discocyclina thalica n.sp. (Text, pp.49-50.)

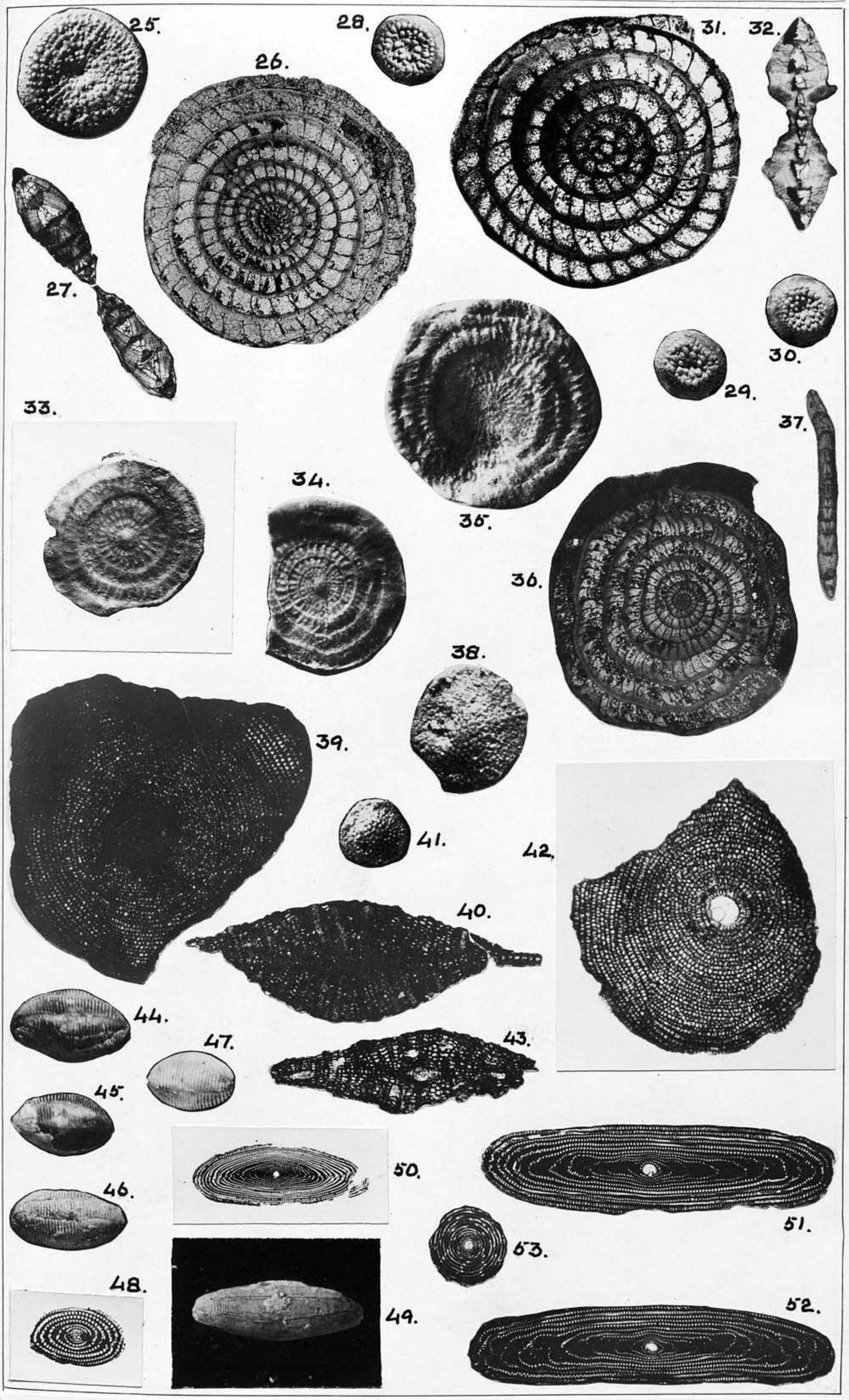
Figures 41-43: Discocyclina subthalica n.sp. (Text, p.50.)

Figures 44-48: Alveolina ellipsoidalis Schwager. (Text, pp. 51-52.)

Figures 49-50: Alveolina vredenburgi Davies. (Text, pp.52-53.)

Figures 51-53: Alveolina violae Checchia-Rispoli. (Text, pp. 54-55.)

ILLUSTRATIONS.
FIGS. 25 TO 53.



ASSILINES, DISCOCYCLINES AND ALVEOLINES.

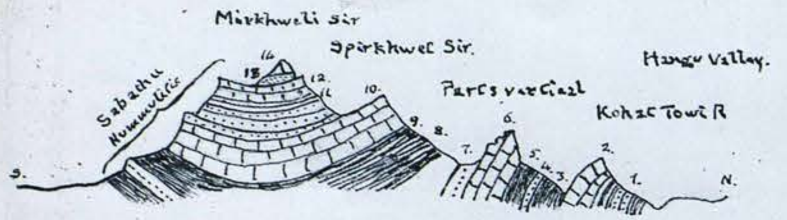
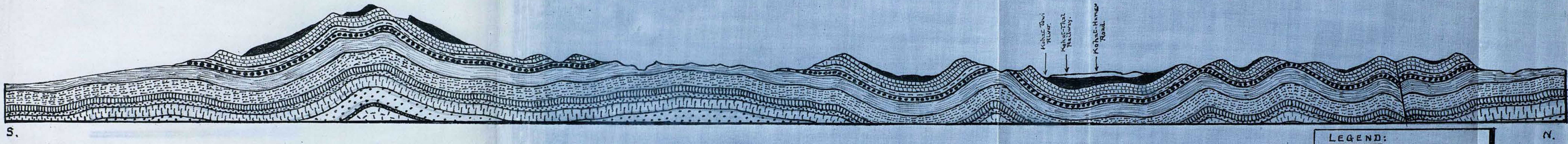


Fig. 1. Sketch section over Mirkhwali Sir. Numbers refer to succession in Text.

SECTION No.1: About 8 Miles E.N.E. of Hangu, corresponding with Wynne's Fig. 1 (reproduced to left).
Scale 2" = 1 Mile. Vertical and horizontal scales alike.



SECTION No.2: Through Darsamand Mountain, corresponding with Wynne's Fig. 2 (reproduced to left).
Scale 4" = 1 Mile. Vertical and horizontal scales alike.

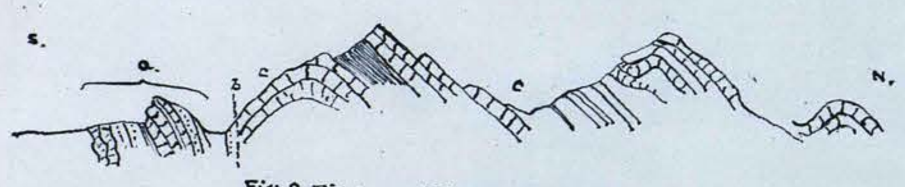


Fig. 2. Diagram of Darsamand Hills
a. Nummulitic beds. b. Fault. c. Mesozoic Limestones and shales.